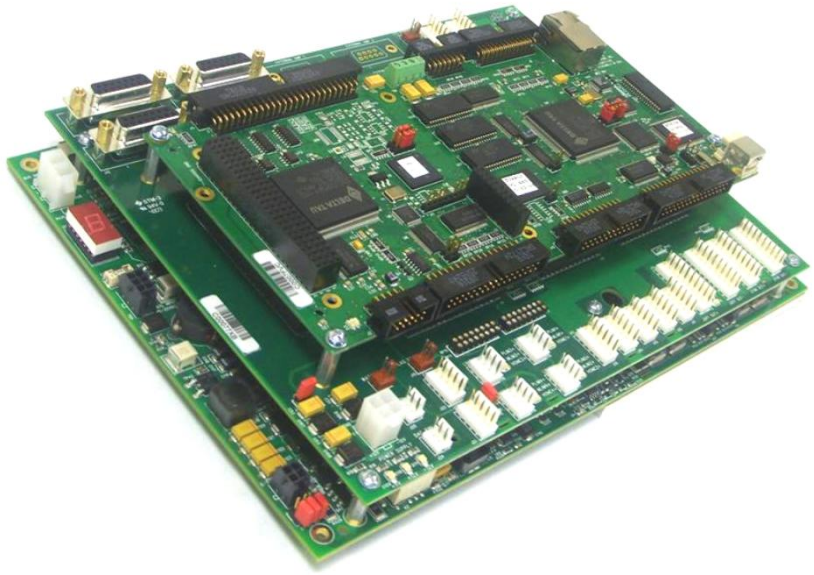
USER MANUAL

Turbo Clipper Drive



4-Axis Low Voltage Intelligent Amplifier

TCD 4-XX-400-0X1-0XXX

November 19, 2013

DELTA TAU
Data Systems, Inc.
NEW IDEAS IN MOTION ...

Single Source Machine Control *Power // Flexibility // Ease of Use*
21314 Lassen Street Chatsworth, CA 91311 // Tel. (818) 998-2095 Fax. (818) 998-7807 // www.deltatau.com

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Operating Conditions

All Delta Tau Data Systems, Inc. motion controller products, accessories, and amplifiers contain static sensitive components that can be damaged by incorrect handling. When installing or handling Delta Tau Data Systems, Inc. products, avoid contact with highly insulated materials. Only qualified personnel should be allowed to handle this equipment.

In the case of industrial applications, we expect our products to be protected from hazardous or conductive materials and/or environments that could cause harm to the controller by damaging components or causing electrical shorts. When our products are used in an industrial environment, install them into an industrial electrical cabinet or industrial PC to protect them from excessive or corrosive moisture, abnormal ambient temperatures, and conductive materials. If Delta Tau Data Systems, Inc. products are exposed to hazardous or conductive materials and/or environments, we cannot guarantee their operation.

MANUAL REVISION HISTORY				
REV.	**DESCRIPTION**	**DATE**	**CHANGE**	**APPROVED**
1	PRELIMINARY MANUAL CREATION	07/01/10	M.Y	R.N
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5	CORRECTED PIN-OUT, PAGE 43	04/18/11	M.Y	R.N
6	FORMAT. FIXED LABES J37	12/18/12	R.N	R.N
7	ADDED E4 JUMPER IN REV103	11/19/13	M.C	R.N

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INTRODUCTION

The Turbo Clipper Drive (**L**ow **V**oltage), 12~60V(DC) bus power input, combines the intelligence and capability of the Turbo PMAC2 motion controller with the latest MOSFET technology, resulting in a compact 4-axis smart servo package. The flexibility of the Turbo PMAC2 enables the Turbo Clipper Drive to drive Stepper, Brush, or Brushless motors with unsurpassed pure digital DSP performance.
The Turbo Clipper Drive also features a wide variety of options varying from processor speeds as high as 240MHz, multiple digital and analog inputs/outputs, USB2.0, Ethernet 100 Base T, and serial communication.

Documentation

In conjunction with this hardware reference manual, the Turbo Software Reference Manual and Turbo PMAC User Manual are essential for proper use, motor setup, and configuration of the Turbo Clipper Drive. It is highly recommended to always refer to the latest revision of the manuals found on Delta Tau's website, under Support>documentation>Manuals: Delta Tau Manuals Link

Turbo Clipper Drive Features

The Turbo Clipper Drive supports the following types of motors:

- Three-Phase DC Brushless
- DC Brush
- 2-Phase Stepper

Some of the Turbo Clipper Drive's outstanding features:

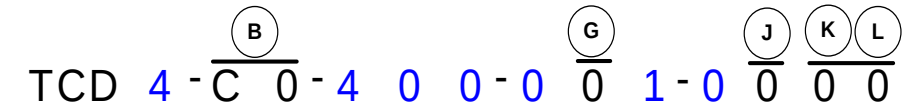
- 4 channel direct digital PWM control
- Integral 4 servo amplifiers delivering 5Amps continous/15Amps peak per axis
- Protection: over voltage, under voltage, over temperature, short circuit, over current
- Motorola DSP 56k digital signal processor
- Turbo PMAC2 CPU
- Linear and circular interpolation
- 256 fixed motion program buffers
- 64 asynchronous PLC programs
- Rotary buffer support
- 36-bit position range (± 64 billion counts)
- Adjustable S-curve acceleration and deceleration
- Cubic trajectory calculations, Splines, PVT
- Set and change parameters in real time and on-the-fly, alter destination moves
- Torque, Velocity and Position control
- Small space-saving footprint
- USB2.0, Ethernet 100 Base T
- Operation from PC or standalone

SPECIFICATIONS

Part Number

Delta Tau Assembly Numbers (top to bottom):	Control Board (Clipper)	603871
	Breakout Board	603926
	Power Board	603925

Turbo Clipper Drive (Control+Breakout+Power)



B

CPU Options - Turbo PMAC 2 Processor

C0 - 80Mhz, 8Kx24 Internal, 256Kx24SRAM, 1MB Flash (Default)
C3 - 80Mhz, 8Kx24 Internal, 1Mx24SRAM, 4MB Flash
F3 - 240Mhz, 192Kx24 Internal, 1Mx24SRAM, 4MB Flash

J

Other Options
0 - No Options (Default)
1 - Opt. 11A HI-Speed Dig. Out PWM Laser Control

G

Communication Options

TCD X - XX - XXX – X?X - XXXX
USB2 and Eth100 are included
Note: To use PMAC-NC software, DPRAM is required

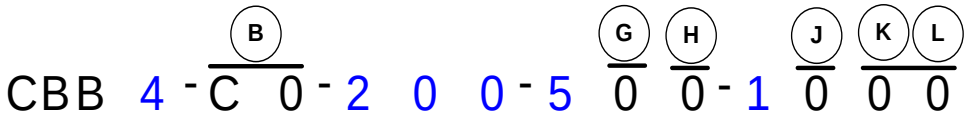
0 - No Options, Default
D - (**Clipper OPT-2**) DPRAM option, size 8K x 16-bit wide
M - (**Clipper Opt-15M**) ModBus Ethernet Communication Protocol(Software) option
S - (**Clipper OPT-2 and Opt-15M**) DPRAM and Modbus Options Combined

K **L**

Factory Assigned Options
00 - No **Additional*** Options
xx - Factory assigned digits for **Additional*** Options

***** If **Opt. 10xx** (**specific firmware version**) or any other **Additional Option** is required, contact factory for digits **K** and **L** (**Factory Assigned** digits). If Opt. 10xx is not ordered the latest firmware is used.

Clipper & Breakout only (Control+Breakout, without Power)



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CPU Options - Turbo PMAC 2 Processor

C0 - 80Mhz, 8Kx24 Internal, 256Kx24SRAM, 1MB Flash (Default)
C3 - 80Mhz, 8Kx24 Internal, 1Mx24SRAM, 4MB Flash
F3 - 240Mhz, 192Kx24 Internal, 1Mx24SRAM, 4MB Flash

G

Communication Options

CBB X - XX - XXX – X?X - XXXX
USB2 and Eth100 are included
Note: To use PMAC-NC software, DPRAM is required

0 - No Options, Default
D - (**Clipper OPT-2**) DPRAM option, size 8K x 16-bit wide
M - (**Clipper Opt-15M**) ModBus Ethernet Communication Protocol(Software) option
S - (**Clipper OPT-2 and Opt-15M**) DPRAM and Modbus Options Combined

H

0 - No Options (Default)
1 - Opt. 12 2-channels 12-bit A/D converter & 1 12-bit D/A converter

J

0 - No Options (Default)
1 - Opt. 11A HI-Speed Dig. Out PWM Laser Control

Other Options

K **L**

Factory Assigned Options
00 - No **Additional*** Options
xx - Factory assigned digits for **Additional*** Options

***** If **Opt. 10xx** (**specific firmware version**) or any other **Additional Option** is required, contact factory for digits **K** and **L** (**Factory Assigned** digits). If Opt. 10xx is not ordered the latest firmware is used.

Electrical Specifications

Specification	Description	Range
Max ADC	Full Range ADC reading (RMS/Axis) Used in I2T Calculation	33.85 Amps
Bus Power Supply	Input Voltage	12~60VDC
	Continuous Input Current (RMS)	12.5A
	Peak Input Current (RMS)	25A @ 1s
Logic Power Supply	Input Voltage	24VDC ±20%
	Continuous Input Current	2~3A (RMS)
Output Current	Nominal Current per axis (RMS)	5A
	Maximum Peak Current per axis (RMS)	15A @ 1s
Power Dissipation	240W per axis (modulation depth of 60%)	
PWM Frequency	2K~40KHz / recommended 20KHz	

Environmental Specifications

Specification	Description	Range
Ambient operating Temperature EN50178 Class 3K3 – IEC721-3-3	Minimum operating temperature	0°C (32°F)
	Maximum operating temperature	45°C (113°F)
Storage Temperature Range EN 50178 Class 1K4 – IEC721-3-1/2	Minimum Storage temperature	-25°C (-13°F)
	Maximum Storage temperature	70°C (158°F)
Humidity Characteristics w/ no condensation and no formation of ice IEC721-3-3	Minimum Relative Humidity	5% HU
	Maximum Relative Humidity up to 35°C (95°F)	95% HU
	Maximum Relative Humidity from 35°C up to 50°C (122°F)	85% HU
De-rating for Altitude	0~1000m (0~3300ft)	No de-rating
	1000 ~3000m (3300~9840ft)	-1%/m (-0.33%/ft)
	3000 ~4000m (9840~13000ft)	-2%/m (-0.67%/ft)
Environment ISA 71-04	Degree 2 environments	
Atmospheric Pressure EN50178 class 2K3	70 KPa to 106 KPa	
Shock	Unspecified	
Vibration	Unspecified	
Air Flow Clearances	3" (76.2mm) above and below unit for air flow	
Cooling	Natural convection and external fan	
Standard IP Protection	IP20 IP 55 can be evaluated for custom applications	

RECEIVING AND UNPACKING

Delta Tau products are thoroughly tested at the factory and carefully packaged for shipment. Upon receipt of hardware, please follow carefully the instructions below for proper maintenance and handling:

Observe the condition of the shipping container and report any damage immediately to the commercial carrier.

Remove the hardware from the shipping container and remove all packing materials. Check all shipping material for connector kits and documentation. Some components may be quite small and can be accidentally discarded if care is not used when unpacking the equipment. The container and packing materials may be retained for future shipment.

Verify that the part number of the unit received matches the part number listed on the purchase order.

Inspect the drive for external physical damage that may have been sustained during shipping and report damages immediately to the commercial carrier. Document any damage with photographs.

Electronic components in this unit are design-hardened to reduce static sensitivity. However, use proper procedures when handling the equipment to avoid electrostatic discharges (ESD).

If the Turbo Clipper Drive is to be stored for several weeks before integration (i.e., spare part), be sure that it is stored in a location that conforms to environmental specifications. Also, testing of the unit is highly recommended before storing it for future use.

Use of Equipment

The following restrictions will ensure the proper use of the Turbo Clipper Drive:

The components built into electrical equipment or machines can be used only as integral components of such equipment.

The Turbo Clipper Drive must not be operated on power supply networks without a ground or with an asymmetrical ground.

If the Turbo Clipper Drive is used in residential areas, or in business or commercial premises, implement additional filter measures.

The Turbo Clipper Drive may be operated only in a closed switchgear cabinet, taking into account the ambient conditions defined in the environmental specifications.

Delta Tau guarantees the conformance of the Turbo Clipper Drive with the standards for industrial areas stated in this manual only if Delta Tau components (cables, accessories, etc.) are used.

Mounting

The drive placement in the machine cabinet is important. Installation should be in an area that is protected from direct sunlight, corrosives, harmful gases or liquids, dust, metallic particles, and other contaminants. Exposure to these conditions can reduce the operating life and degrade performance of the drive.

Several other factors should be carefully evaluated when selecting a location for installation:

For effective cooling and maintenance, the control should be mounted on a smooth, non-flammable vertical surface.

At least 76 mm (~3 inches) top and bottom clearance must be provided for air flow. At least 10 mm (~0.4 inches) clearance is required between amplifier, breakout board and clipper.

Temperature, humidity and Vibration specifications should also be taken in account.

The Turbo Clipper Drive can be mounted with a traditional 4-hole panel mount. This keeps the heat sink and fan inside the mounting enclosure.

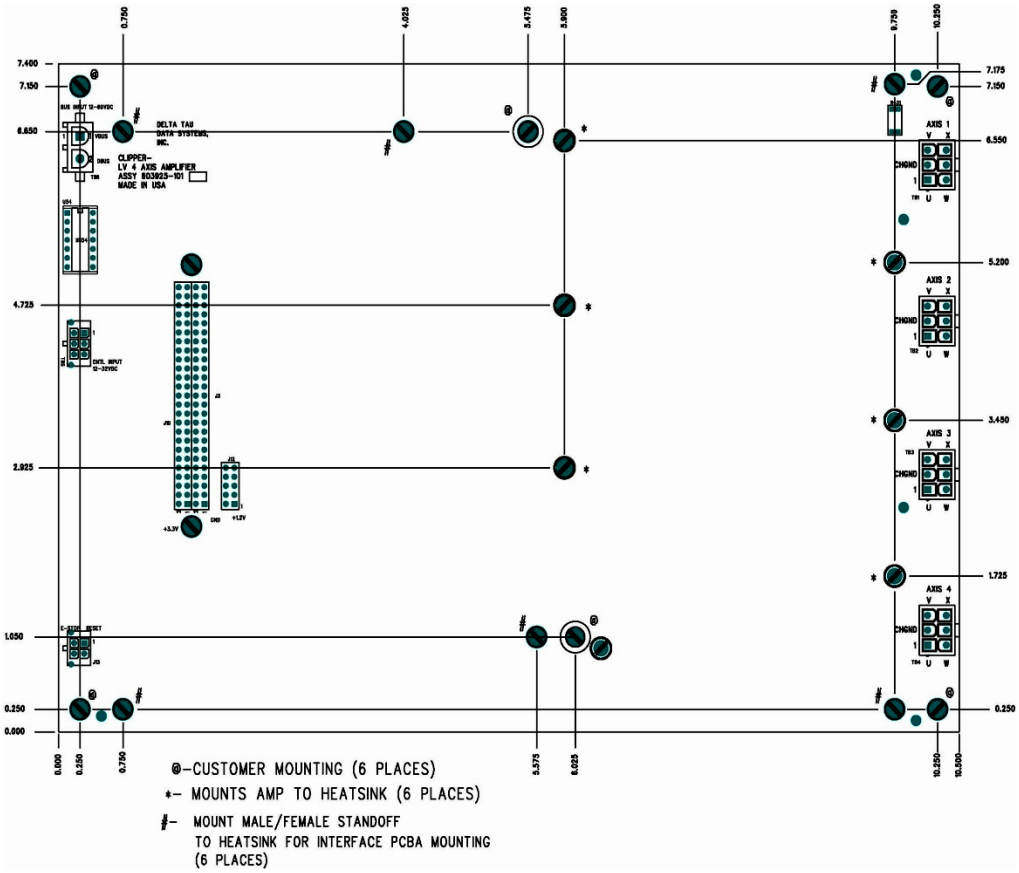
If multiple Turbo Clipper Drive Drives are used, they can be mounted side by side, leaving at least 122 mm (~5 inches) center to center clearance. It is extremely important that the airflow is not obstructed by the placement of conduit tracks or other devices in the enclosure.

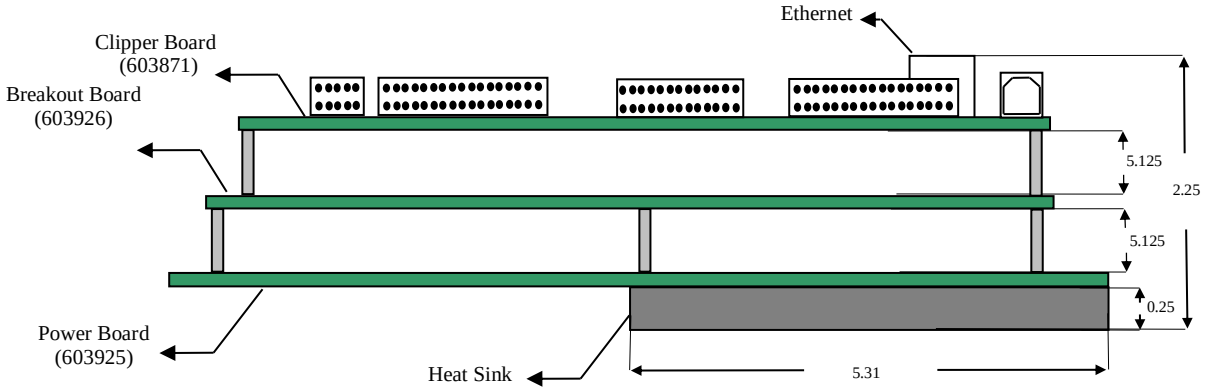
If the drive is mounted to a back panel, the panel should be unpainted and electrically conductive to allow for reduced electrical noise interference. The back panel should be machined to accept the mounting bolt pattern of the drive. Make sure that all metal chips are cleaned up before the drive is mounted so there is no risk of getting metal chips inside the drive.

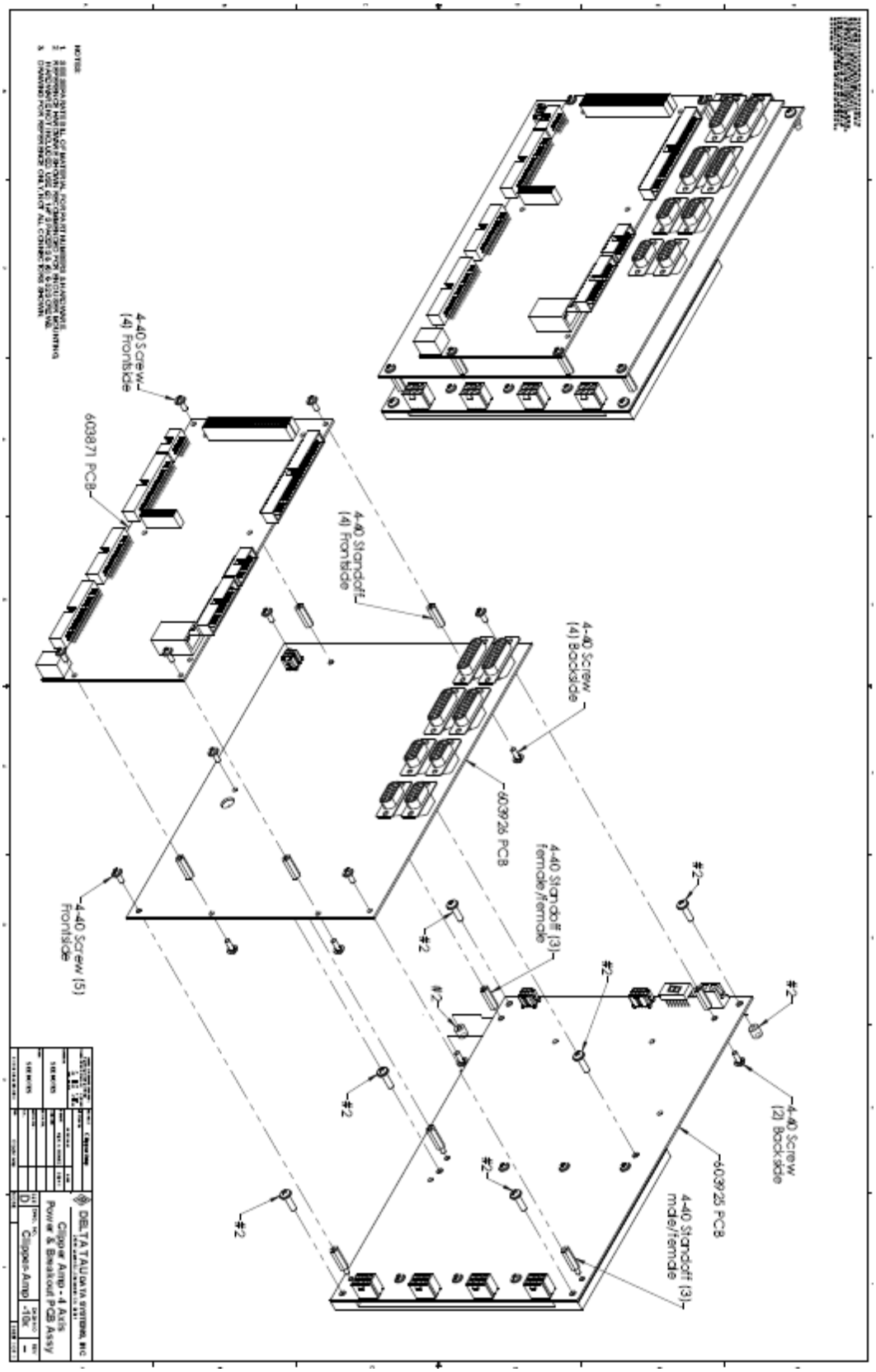
The drive is mounted to the back panel with four M4 screws and internal-tooth lock washers. It is important that the teeth break through any anodization on the drive's mounting gears to provide a good electrically conductive path in as many places as possible. Mount the drive on the back panel so there is airflow at both the top and bottom areas of the drive (at least three inches).

CAD drawing below shows the location of screws for mounting the drive to plate and mounting the breakout board to the drive.

CAD Drawing


@–CUSTOMER MOUNTING (6 PLACES)
*– MOUNTS AMP TO HEATSINK (6 PLACES)
#– MOUNT MALE/FEMALE STANDOFF
TO HEATSINK FOR INTERFACE PCBA MOUNTING
(6 PLACES)


Ethernet
Clipper Board
(603871)
Breakout Board
(603926)
5.125
2.25
5.125
0.25
Power Board
(603925)
Heat Sink
5.31


4-40 Screw
(4) Frontside
603871 PCB
4-40 Standoff
(4) Frontside
4-40 Screw
(4) Backside
603926 PCB
4-40 Standoff (3)
female/female
4-40 Screw (5)
Frontside
#2
4-40 Screw
(2) Backside
603925 PCB
4-40 Standoff (3)
male/female
DELTA TAU DATA SYSTEMS, INC.
Clipper Amp - 4 Axis
Power & Breakout PCB Assy
Clippers-Amp
-10x
D

POWER BOARD: WIRING, SOFTWARE SETUP

WARNING

Installation of electrical control equipment is subject to many regulations including national, state, local, and industry guidelines and rules. General recommendations can be stated but it is important that the installation be carried out in accordance with all regulations pertaining to the installation.

TB1-TB4: Motor Wiring

Motor phases are conversed in one of three conventions. Some motor manufacturers will call the motor phases A, B, or C. Other motor manufacturers call them U, V, W. The Turbo Clipper Drive outputs are called U, V, W, and X. For DC brushless motors (servo) use U,V and W, let X float. For stepper motors, use U and W for one coil, V and X for the other coil. For DC Brush motors, use U and W, float V and X. The motor's frame drain wire and the motor cable shield must be tied together and wired at the GND pin of the motor connector (Pin 5 or 2).

TB1-TB4: Molex (F)
Molex Mating Connector Part #: 39-01-2065 (M)
Molex Crimper Pin Part #: 39-00-0060

For Internal Use:
DT Part #: 014-390120-065
DT Part #: 014-555656-083

Pin #	Symbol	Description
1	U Phase	Axis 1-4
2	GND	Ground
3	V Phase	Axis 1-4
4	W Phase	Axis 1-4
5	GND	Ground
6	X Phase	Axis 1-4

Note

- DC Brushless motors: Use U, V and W. Leave X floating
- Stepper motors: Use U and W at one coil, V and X at the other coil.
- Brush motors: Use U and W. Leave V and X floating.
- The cable wiring must be shielded and have a separate conductor connecting the motor frame back to the assembly ground.

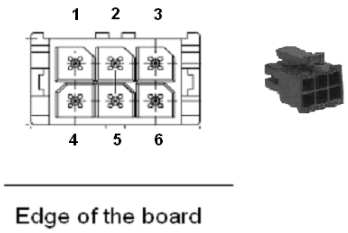
TB5: 24-Volt Logic Power

An external 24Vdc power supply is required to power up the logic portion of the Turbo Clipper Drive. This power can remain on, regardless of the main DC bus power, allowing the signal electronics to be active while the main motor power control is inactive. The 24V is wired into terminal block TB5. The polarity of this connection is extremely important. Carefully follow the instructions in the wiring diagram. This connection can be made using 22 AWG wire directly from a protected power supply. In situations where the power supply is shared with other devices, it may be desirable to insert a filter in this connection.

The 24Volts power supply must be capable of providing 2~3Amps per Turbo Clipper Drive to allow proper functionality. If multiple drives are sharing the same 24Volts power supply, it is highly recommended to wire each drive back to the power supply terminals separately.

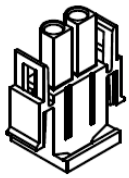
TB5: Molex (F)
Molex Mating Connector Part #: 43025 (M)
Molex Crimper Pin Part #: 43030-0008

For Internal Use:
DT Part #: 014-430250-600
DT Part #: 014-43030-008



Pin #	Symbol	Function	Description	Notes
1	24VDC	Input	Logic power input	+16~32VDC
2	NA	NA	NA	NA
3	24VDC RET	Common	Logic power return	Power Supply Return
4	24VDC	Input	Logic power input	+16~32VDC
5	NA	NA	NA	NA
6	24VDC RET	Common	Logic power return	Power Supply Return

TB6: Bus Voltage

TB6: Molex (F) **Molex Mating Connector Part #:: 50-84-1020 (M)** **Molex Crimper Pin Part #: 002081001** **For Internal Use:** **DT Part #: 014-030f02-HSM** **DT Part #: 014-002081-001**				
Pin #	**Symbol**	**Function**	**Description**	Notes
1	+12~60VDC	Input	Bus power input VBus	+12~60VDC
2	+12~60VDC RET	Common	Bus power return 0Bus	+12~60VDC RET

Recommended Fuse, and wire gauge:

Fuse (FRN/LPN)	**Wire Gauge**
15	12 AWG

J13: E-Stop, Reset

TB6: Molex (F) **Molex Mating Connector Part #: 430250-0400 (M)** **Molex Crimper Pin Part #: 43030-0008** **For Internal Use:** **DT Part #: 014-430250-400** **DT Part #: 014-43030-008**		
Pin #	**Symbol**	**Description**
1	Reset	Connect 1-2 to activate the reset.
2	Reset	
3	E-STOP	Connect 3-4 to engage the E-Stop
4	E-STOP	

The Turbo Clipper Drive is equipped with a built-in Emergency Stop circuitry. It utilizes two latching type relays to enable/disable the drive's Mosfet transistors. Additionally, the following safety and status features are implemented:

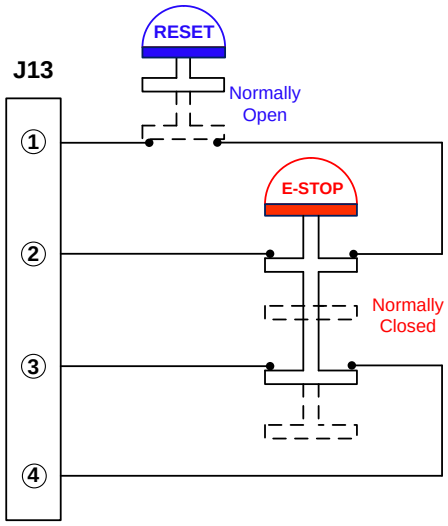
- The E-Stop status, by default, is conveyed to the Turbo Clipper via User Flag Input #4 (X:$78018,19).See jumper J39.
- The General Purpose Outputs (GPO), by default, is independent of the E-Stop status. They can be disabled in an emergency stop condition. See jumper J36.
- The Turbo Clipper Drive has an E-Stop software controllable enable bit (Y:$78402,15,1). It is a low true logic meaning =0 to engage E-Stop, =1 to disengage E-Stop, allowing the user to trigger an emergency stop condition through software logic.

Note

The built-in Emergency Stop circuitry disables the Mosfet transistors but does NOT remove power from the DC bus. If this additional level of protection is required, it is recommended to add a separate external device to remove the DC Bus input from the Turbo Clipper Drive.

Wiring The E-Stop, And Reset Switch

The E-Stop button should be a normally-closed switch, so that the circuit is closed when it is released and open when it is pressed.
The Reset button should be a normally-open switch before revision 103, so that the circuit is open when it is released and closed when it is pressed. Revision 103 and after the type of Reset button can be selectable via jumper E4.

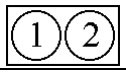
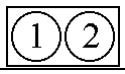
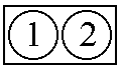
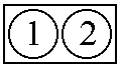
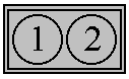
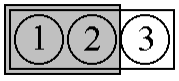


Note

It is recommended to wire the E-Stop in series with the reset circuit, so if the machine is in an emergency stop condition, the reset cannot be activated and has no practical use.

Emergency Stop, Reset Jumpers Summary

The following table summarizes the E-Stop and Reset features. The hard E-Stop designates the actual hardware E-Stop button. The soft E-Stop designates the software controllable E-Stop bit:

Board	Jumper	Function	Default
Power	**E1** 	Remove to enable the hard E-Stop function. Install to disable the hard E-Stop function.	Not Installed
Power	**E2** 	Remove to enable hard & soft E-Stop functions. Install to disable hard & soft E-Stop functions.	Not Installed
Power	**E3** 	Remove to enable the soft E-Stop function. Install to disable the soft E-Stop function (Soft E-Stop bit has to be set, and saved to 1).	Not Installed
Power	**E4** 	Remove jumper to use normally-open Reset switch between pin 1 and 2 of J13. Install jumper to use normally-closed Reset switch between pin 1 and 2 of J13.	Not Installed
Breakout	**J36** 	Install jumper to disable the GPO E-Stop automatic feature (outputs unaffected by E-Stop status). Remove Jumper to enable the GPO E-Stop automatic feature (turn outputs off when in E-Stop)	Installed
Breakout	**J39** 	Jump 1 to 2 to use User Flag 4 as an E-Stop status in software. Jump 2 to 3 to use User Flag 4 as a general purpose user input.	Jumpered 1-2

Note

Upon releasing the E-Stop, the General Purpose Outputs (GPO) state, otherwise handled by PLC/software, is re-established to what it was prior to pressing the E-Stop.

Emergency Stop-Reset Example PLC

In addition to the automatic Emergency Stop functionality a PLC must be used to insure proper and complete Emergency Stop function once the Mosfet transistors are disabled. During an emergency stop condition, it is highly advised to implement the following:

- Kill motors.
- Turn off general purpose outputs (GPOs).
- Other functions insuring machine safety.

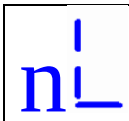
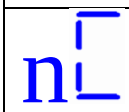
With E1, E2, E3, and E4 removed allowing both hardware and software E-Stop functionality. J36 removed, to automatically turn off the general purpose outputs, and J39 set to 1-2 to allow reading the E-Stop status through User flag4:

```
// Definition and Substitutions
#define Estop_Latch    P8000   ; General purpose Latching flag
#define Estop_Enable   M47     ; Software Controllable E-Stop Bit
Estop_Enable->Y:$78402,15,1    ; =0 E-Stop, =1 Not in E-Stop
Estop_Enable=1

#define Estop_Status   M415    ; S-Stop Status Bit, using User Flag 4
Estop_Status->X:$78018,19      ; =1 E-Stop, =0 Not in E-Stop


Open PLC 1 Clear
// Is E-Stop Pressed?
If (Estop_Status=1)
 Estop_Latch=0
Else
 Estop_Latch=1
EndIF
Estop_Enable=1 ; Set once on power-up
While (1=1)
  // Emergency Stop Engaged
  If(Estop_Status = 1 and Estop_Latch = 0)
   // Put Emergency Stop Functions Here
   &1 CMD^K    ; Kill all axes in Coordinate System 1
   // Set desired Outputs state (post E-Stop) here
   // if automatic GPO kill is enabled
   Estop_Latch = 1
  Else
   // Emergency Stop Released
   IF(Estop_Status = 0 and Estop_Latch = 1)
    // Put Emergency Stop Release Functions Here
    &1 CMD^A   ; Enable all axes in Coordinate System 1
    Estop_Latch = 0
    P8002=P8002+1
   EndIf
  EndIf
Endwhile
Close
```

D1: AMP STATUS

The Turbo Clipper Drive utilizes a scrolling single-digit 7-segment display to exhibit faults to the outside world. When control and DC bus power are applied, the Drive will display a solid dot indicating that the software and hardware are running normally.

Error Codes

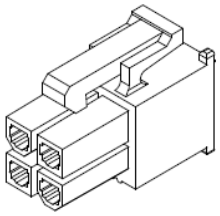
Display	Description
	Global Faults
	Under Voltage Fault: Indicates that the bus voltage is not present or less than 12Volts
	Over Voltage Fault: Indicates that the bus voltage has exceeded 60Volts
	Over Temperature Fault: Indicates that the Board has exceeded 65°C
	Axis n Faults (n=1 thru 4)
	Axis n Over load Fault: Indicates that the current rating (5/15A) of the drive has been exceeded
	Axis n Over Current Fault: Indicates that the peak current value has exceeded the permissible limit(20Amps)

BREAKOUT BOARD: WIRING, SOFTWARE SETUP

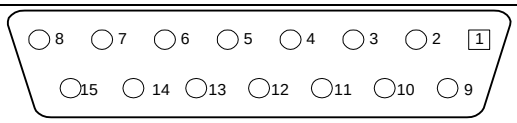
TB1: External Power Supply

Caution

This connector is only used if the power board is not present. It is utilized to bring in logic power to the control (Clipper) and breakout boards.

TB1: Molex (F) **Molex Mating Connector Part #:: 39-01-2045 (M)** **Molex Crimper Pin Part #: 39-00-0060** **For Internal Use:** **DT Part #: 014-390120-045** **DT Part #: 014-555656-083**			
Pin #	**Symbol**	**Function**	**Notes**
1	GRD	Input	Ground
2	+5 VDC	Input	5 volt Input
3	+12 VDC	Input	12 volt Input
4	-12 VDC	Input	-12 volt Input

J11-J14: Encoder Feedback, Digital A Quad B

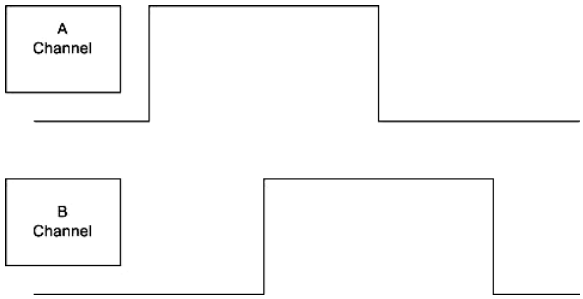
J11-J14: D-sub DA-15F **Mating: D-sub DA-15M**			
Pin#	**Symbol**	**Function**	**Description**
1	CHA+	Input	Axis Encoder A+
2	CHB+	Input	Axis Encoder B+
3	CHC+	Input	Axis Encoder Index+
4	ENCPWR	Output	Encoder Power 5V
5	CHU+ / DIR+	In/Out	Halls U+ / Direction Output + for Stepper
6	CHW+/ PUL+	In/Out	Halls W+ / Pulse Output + for Stepper
7	2.5V	Output	2.5V Reference power
8	Stepper Enable	Input	Tie to pin#4 (5V) to enable stepper output
9	CHA-	Input	Axis Encoder A-
10	CHB-	Input	Axis Encoder B-
11	CHC-	Input	Axis Encoder Index-
12	GND	Common	Common ground
13	CHV+ / DIR-	In/Out	Halls V+ / Direction Output- for Stepper
14	CHT+ / PUL-	In/Out	Halls T+ / Pulse Output- for Stepper
15	N/C	-	Reserved for future use

Note

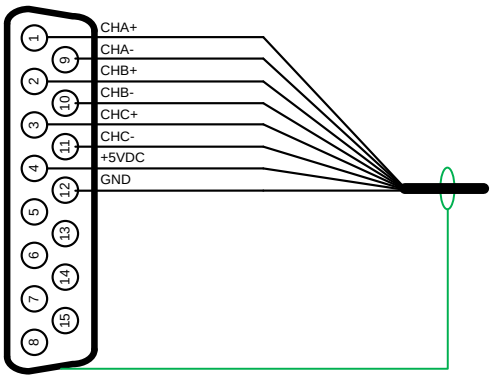
Spacing specs between DB-Connectors can be found in Appendix section.

The standard encoder input channels on the Turbo Clipper Drive Drive are designed for differential quadrature feedback. To use single-ended encoders, the negative pins (i.e. CHAn-) have to be tied to reference (Pin#7) in series with a 1Kohm resistor.

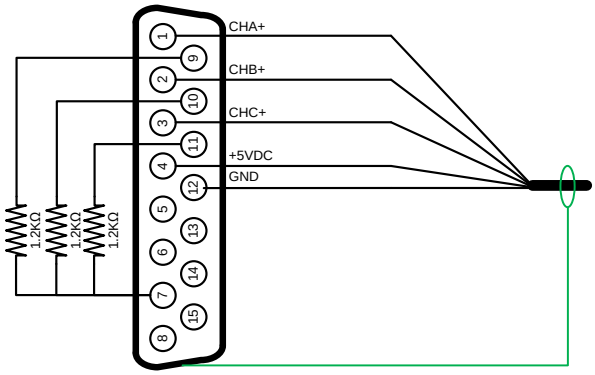
Quadrature encoders provide two digital signals to determine the position of the encoder/motor. Each nominally with 50% duty cycle, and nominally 1/4 cycle apart. This format provides four distinct states per cycle of the signal, or per line of the encoder. The phase difference of the two signals permits the decoding electronics to discern the direction of travel, which would not be possible with a single signal.



Typically, these signals are 5V TTL/CMOS level, whether they are single-ended or differential. Differential encoder signals can enhance noise immunity by providing common mode noise rejection. Modern design standards virtually mandate their use in industrial systems.



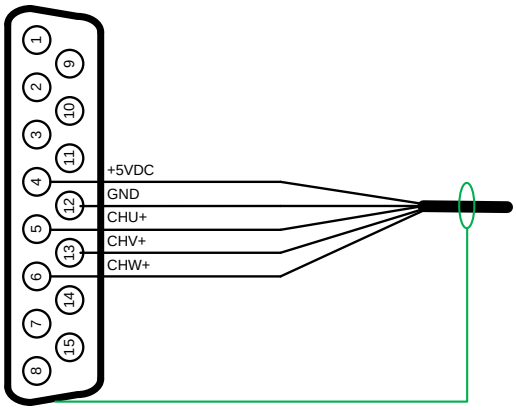
Differential Quadrature Encoder Wiring



Single-Ended Quadrature Encoder Wiring

Note

For single-ended encoders, tie the negative pins (i.e. CHAn-) to reference (Pin#7) in series with a 1Kohm resistor.



Hall-Effect Sensor Wiring

Motor Activation: Ixx00

Digital Quadrature Encoders use the 1/T incremental entry in the encoder conversion table. Position and Velocity pointers are by default valid and in most cases no special software setup is required, activating the motor(s) is sufficient to see encoder counts in the position window when the motor/encoder shaft is moved by hand.

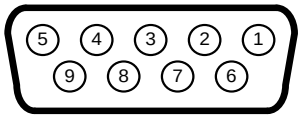
```
I100,4,100=1   ; Motors 1-4 activated
```

Note

At this point of the setup, you should be able to move the motor/encoder shaft by hand and see ‘motor’ counts in the position window

ACC-51S: Sinusoidal Feedback (Optional)

The accessory ACC-51S allows the Turbo Clipper Drive to interface to up to 4 sinusoidal feedback devices. This high resolution interpolator circuitry accepts inputs from sinusoidal or quasi-sinusoidal encoders (1-Volt peak to peak) and provides encoder position data. It creates 4,096 steps per sine-wave.

J9-J12: D-Sub DE-9F Mating: D-Sub DE-9M				
Pin #	**Symbol**	**Function**	**Description**	**Notes**
1	SIN +	Analog Input	Sinusoidal input+	
2	COS +	Analog Input	Cosine input+	
3	INDEX +	Input	Index input	Analog or TTL levels
4	ENCPWR	Output	Encoder power	+5VDC
5	GND		Digital ground	
6	SIN -	Analog Input	Sinusoidal input-	
7	COS -	Analog Input	Cosine input-	
8	INDEX -	Input	Index input	Analog or TTL levels
9	VREF	2.5V Output	A-D reference output	

```
// Channel 1
I8000=$FF8000  ; High resolution interpolator
I8001=$078B00  ; A/D converter address
I8002=$000000  ; Bias Term and Entry result
// Channel 2
I8003=$FF8008  ; High resolution interpolator
I8004=$078B02  ; A/D converter address
I8005=$000000  ; Bias Term and Entry result
// Channel 3
I8006=$FF8010  ; High resolution interpolator
I8007=$078B04  ; A/D converter address
I8008=$000000  ; Bias Term and Entry result
// Channel 4
I8009=$FF8018  ; High resolution interpolator
I8010=$078B06  ; A/D converter address
I8011=$000000  ; Bias Term and Entry result

I100,4,100=1   ; Axis 1-4 active
```

Position and Velocity feedback pointers should now be set to the corresponding ECT result:

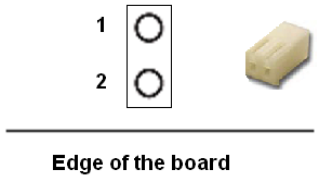
	Position And Velocity Pointers
Channels 1-4	I103=$3503 I104=$3503 I203=$3506 I204=$3506 I303=$3509 I304=$3509 I403=$350C I404=$350C

Note

At this point of the setup, you should be able to move the motor/encoder shaft by hand and see ‘motor’ counts in the position window

J15: Flag(s) Power Supply

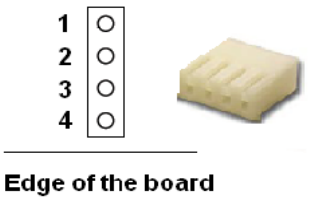
The flag(s) wiring is user configurable; it can be either sinking or sourcing.

J15: Molex (M) **Molex Mating Connector Part #:: 22-01-3027 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R02-LHM** **DT Part #: 025-500114-PNM**	

Sinking Configuration			
Pin #	**Symbol**	**Function**	**Description**
1	24VDC FLA_PWR	Input	Flag Power (+24VDC)
2	24VDC FLA_RET	Input	Flag Return (Common)

Sourcing Configuration			
Pin #	**Symbol**	**Function**	**Description**
1	24VDC FLA_RET	Input	Flag Return (Common)
2	24VDC FLA_PWR	Input	Flag Power (+24VDC)

J16-J19: Axis 1 thru 4 Limits & Home Flags

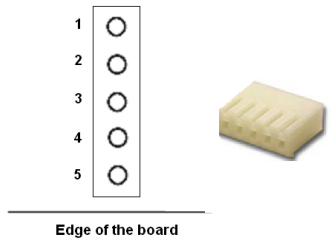
J16/J17/J18/J19: Molex (M) **Molex Mating Connector Part #: 22-01-3047 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R04-LHM** **DT Part #: 025-500114-PNM**			
Pin #	**Symbol**	**Function**	**Description**
1	PLIM +	Input	Positive Limit+
2	MLIM +	Input	Negative Limit+
3	HOME +	Input	Home+
4	FLA_PWR/RET	Common	Flag PWR/RET

The Turbo Clipper Drive limits and flags circuitry offers a flexible 12-24Volts or 5Volts connectivity. In its default configuration, the flags and limits are 12-24Volts inputs. If you are using 5Volt flags and limits, make sure you have ordered the appropriate option before wiring any flags.

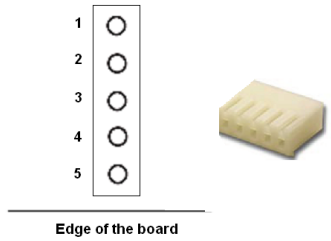
Note

- For 5V flags: Install RP3, RP7, RP11, RP15 (1 kΩ sip).
- SIPs are 8-pin, four independent Resistors.
- For 12-24V flags: Empty bank (default).

J20: Axis 1 thru 4 EQU Outputs

J20: Molex (M) **Molex Mating Connector Part #: 22-01-3057 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R05-LHM** **DT Part #: 025-500114-PNM**			
Pin #	**Symbol**	**Function**	**Description**
1	EQU_1+	Input	Position Compare 1+
2	EQU_2+	Input	Position Compare 2+
3	EQU_3+	Input	Position Compare 3+
4	EQU_4+	Input	Position Compare 4+
5	GND	Common	Ground

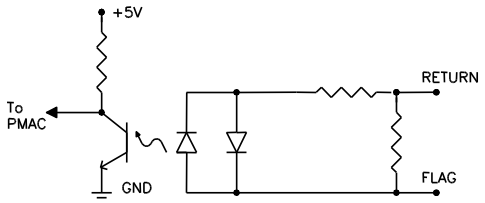
J21: Axis 1 thru 4 User Flags

J21: Molex (M) **Molex Mating Connector Part #: 22-01-3057 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R05-LHM** **DT Part #: 025-500114-PNM**			
Pin #	**Symbol**	**Function**	**Description**
1	USER_1+	Input	User Flag 1+
2	USER_2+	Input	User Flag 2+
3	USER _3+	Input	User Flag 3+
4	USER _4+	Input	User Flag 4+
5	GND	Common	Ground

Limits and Flags (Axis1- 4) Suggested M-Variables

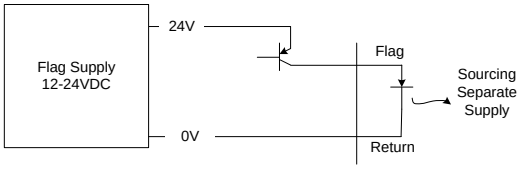
```
M115->X:$078000,19     ; User 1 flag input status
M116->X:$078000,9      ; EQU1, ENC1 compare output value
M120->X:$078000,16     ; Home flag 1 input status
M121->X:$078000,17     ; Positive Limit 1 flag input status
M122->X:$078000,18     ; Negative Limit 1 flag input status

M215->X:$078008,19     ; User 2 flag input status
M216->X:$078008,9      ; EQU2, ENC2 compare output value
M220->X:$078008,16     ; Home flag 2 input status
M221->X:$078008,17     ; Positive Limit 2 flag input status
M222->X:$078008,18     ; Negative Limit 2 flag input status

M315->X:$078010,19     ; User 3 flag input status
M316->X:$078010,9      ; EQU3, ENC3 compare output value
M320->X:$078010,16     ; Home flag 3 input status
M321->X:$078010,17     ; Positive Limit 3 flag input status
M322->X:$078010,18     ; Negative Limit 3 flag input status

M415->X:$078018,19     ; User 4 flag input status
M416->X:$078018,9      ; EQU4, ENC4 compare output value
M420->X:$078018,16     ; Home flag 4 input status
M421->X:$078018,17     ; Positive Limit 4 flag input status
M422->X:$078018,18     ; Negative Limit 4 flag input status
```

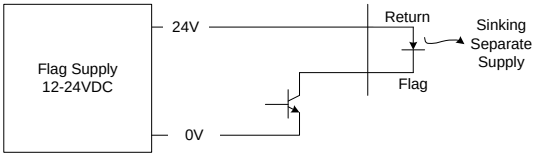
The Turbo Clipper Drive allows the use of sinking or sourcing limits and flags. The opto-isolator IC used is a PS2705-1NEC quad phototransistor output type. This IC allows the current to flow from return to flag (sinking) or from flag to return (sourcing).



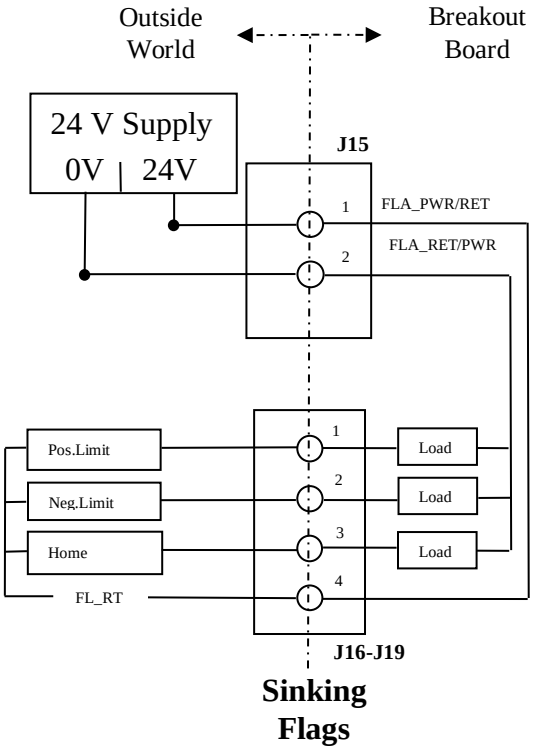
The flags can be sinking and/or sourcing per channel depending on the Flag Input Power Supply J15 wiring.

J15:Power Supply Input		
Sinking/Sourcing	**Pin#1**	**Pin#2**
Sinking	24VDC+	+24VDC RET
Sourcing	+24VDC RET	24VDC+

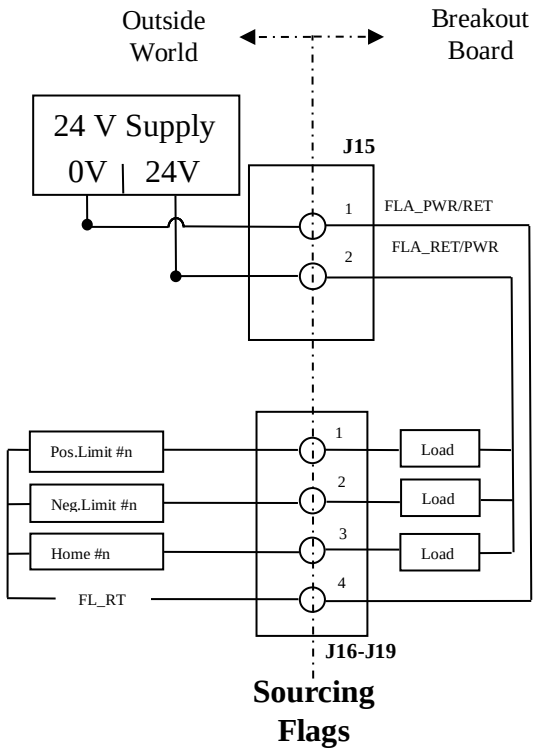




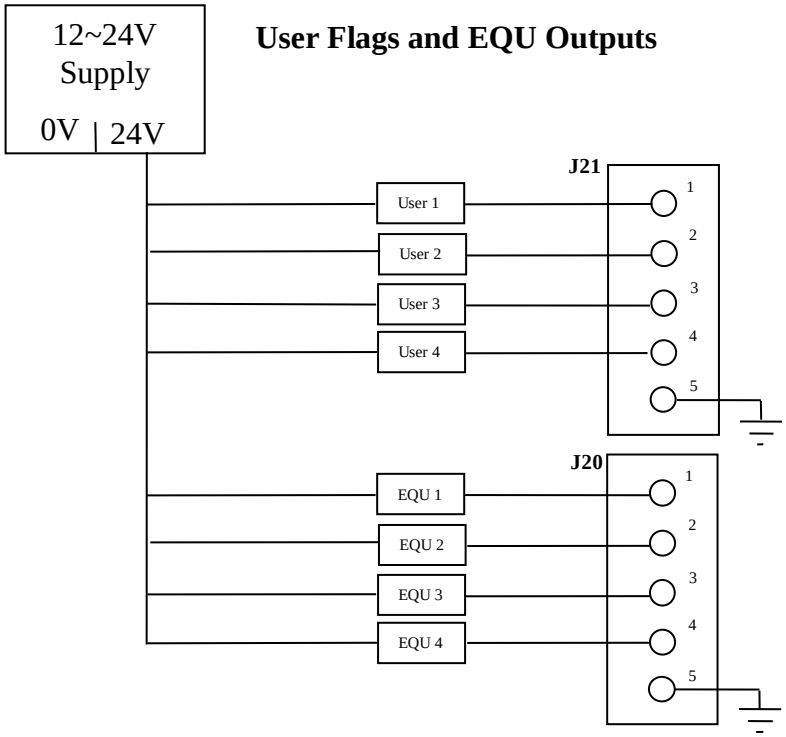
Wiring The Flags



Sinking Flags

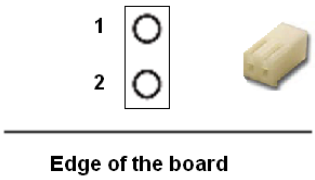


Sourcing Flags



J23: Watchdog Output

This connector allows the user to send Ohm output from the Turbo Clipper Drive to the machine if a watchdog condition has occurred. This is an important safety feature because the Clipper Amp is totally disabled when it is in watchdog condition and this output will allow the other machine's hardware/logic to bring the process to a safe condition. In normal operation there is 5 volts between pin 1 and 2 and in the time of watchdog this will drop to zero.

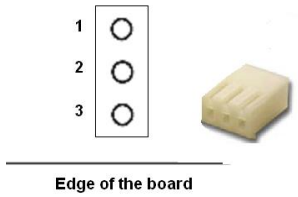
J21: Molex (M) **Molex Mating Connector Part #: 22-01-3027 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R02-LHM** **DT Part #: 025-500114-PNM**			
Pin #	**Symbol**	**Function**	**Description**
1	+5V_5A	Output	5 volts in normal operation
2	B_WDO	Output	Ground

J24: DAC Output, 12-bit Filtered PWM

The Turbo Clipper board, ordered with Option-12, has an additional 12-bit filtered PWM output.

Note

This feature is only available if the power board is not present.

J24: Molex (M) **Molex Mating Connector Part #: 22-01-3037 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R03-LHM** **DT Part #: 025-500114-PNM**			
Pin #	**Symbol**	**Function**	**Description**
1	GRD	Output	Ground
2	DAC_PWM+	Output	DAC Output+
3	DAC_PWM-	Output	DAC Output-

```
I6800= 981              ; PWM frequency ~30kHz
I6801= 5                ; Phase Clock ~10kHz
I6802= 3                ; Servo frequency ~2.5Hz
I6816= 0                ; Output Model PWM
I569= 981               ; DAC limit 10Vdc
I502 =$07841A           ; Only Second output is used
M8000->Y:$7841A,8,16,S ; Supplementary Channel 2* Output A Command Value
                        ; Min=0, Max= Ixx69
```

Testing The Filtered PWM DAC Output

Writing, directly to the suggested M-variable (i.e. M8000), produces corresponding voltages:

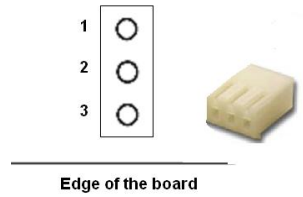
M8000	**DAC (V)**
0	0
981	10

J25: ADC Inputs

The Turbo Clipper board, ordered with Option-12, provides with two single ended 12-bit analog inputs. The ±10V input range corresponds to ±2048 software counts.

Note

This feature is only available if the power board is not present.

J25: Molex (M) **Molex Mating Connector Part #: 22-01-3037 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R03-LHM** **DT Part #: 025-500114-PNM**			
Pin #	**Symbol**	**Function**	**Description**
1	GRD	Input	Ground
2	ADC_IN 1	Input	ADC Input 1
3	ADC_IN 2	Input	ADC Input 2

Setting Up The Analog Inputs:

Bipolar Mode

```
I7003 = 1746                ; Set ADC clock frequency at 4.9152 MHz
I7006 = $1FFFFF             ; ADC Strobe Word
M105->Y:$78005,12,12,S      ; ADC Input 1 on J25 pin 2
M205->Y:$7800D,12,12,S      ; ADC Input 2 on J25 pin 3
```

Unipolar Mode

```
I7003 = 1746                ; Set ADC clock frequency at 4.9152 MHz
I7006 = $1FFFFF             ; ADC Strobe Word
M105->Y:$78005,12,12,u      ; ADC Input 1 on J25 pin 2
M205->Y:$7800D,12,12,u      ; ADC Input 2 on J25 pin 3
```

Testing the Analog Inputs:

	Input Voltage	**Software Counts**
Bipolar	-10	-2048
	-5	-1024
	+10	+2048
	+5	+1024

	Input Voltage	**Software Counts**
Unipolar	+10	+2048
	+5	+1024

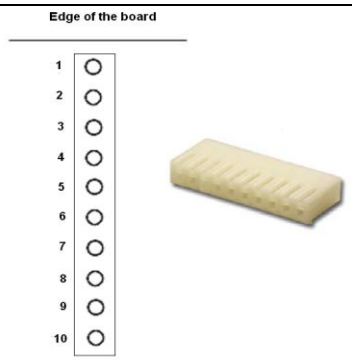
Note

These ADCs do not provide full resolution in Unipolar (0-10V, or 0-5V) mode. Only Bipolar inputs are supported for the full 12-bit (4096 count range) resolution.

J26: Thumbwheel Multiplexer Port Inputs

J26: Molex (M)
Molex Mating Connector p/n#:22-01-3107 (F)
Molex Crimper Pin Part #: 08-50-0114

For Internal Use:
DT Part #: : 014-000W10-LHM
DT Part #: 025-500114-PNM

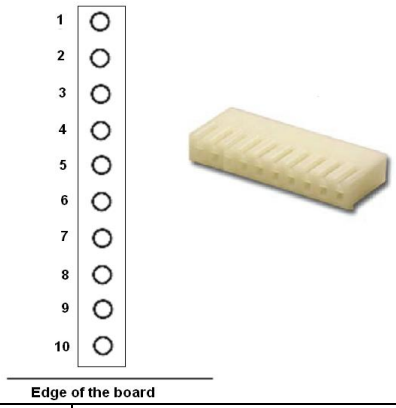


Pin#	Symbol	Function	Description
1	IN_PWR/RET	RTNFL	Return Flag (Tie to 0V or 24V)
2	IN_COM_1	RTNFL	Return Flag (Tie to 0V or 24V)
3	JTHW_IN00	Input	DAT0
4	JTHW_IN01	Input	DAT1
5	JTHW_IN02	Input	DAT2
6	JTHW_IN03	Input	DAT3
7	JTHW_IN04	Input	DAT4
8	JTHW_IN05	Input	DAT5
9	JTHW_IN06	Input	DAT6
10	JTHW_IN07	Input	DAT7

J27: Thumbwheel Multiplexer port Outputs (sinking)

J27: Molex (M)
Molex Mating Connector Part #: 22-01-3107 (F)
Molex Crimper Pin Part #: 08-50-0114

For Internal Use:
DT Part #: : 014-000W10-LHM
DT Part #: 025-500114-PNM

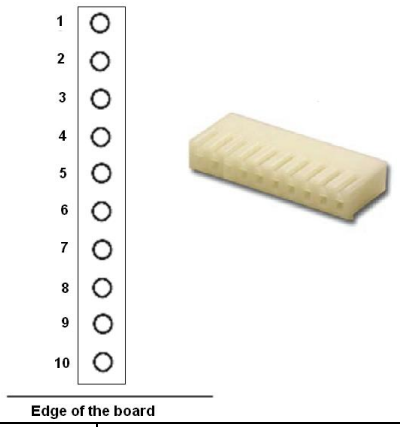


Pin #	Symbol	Function	Description
1	COM_EMT _1	RTNFL	Tie to Common 0V (Sinking)
2	COM_EMT_1	RTNFL	Tie to Common 0V (Sinking)
3	JTHW_OUT1+	Input	SEL 0
4	JTHW_OUT2+	Input	SEL 1
5	JTHW_OUT3+	Input	SEL 2
6	JTHW_OUT4+	Input	SEL 3
7	JTHW_OUT5+	Input	SEL 4
8	JTHW_OUT6+	Input	SEL 5
9	JTHW_OUT7+	Input	SEL 6
10	N/A	N/A	N/A

J37: Thumbwheel Multiplexer port Outputs (Sourcing)

J37: Molex (M)
Molex Mating Connector Part #: 22-01-3107 (F)
Molex Crimper Pin Part #: 08-50-0114

For Internal Use:
DT Part #: 014-000W10-LHM
DT Part #: 025-500114-PNM



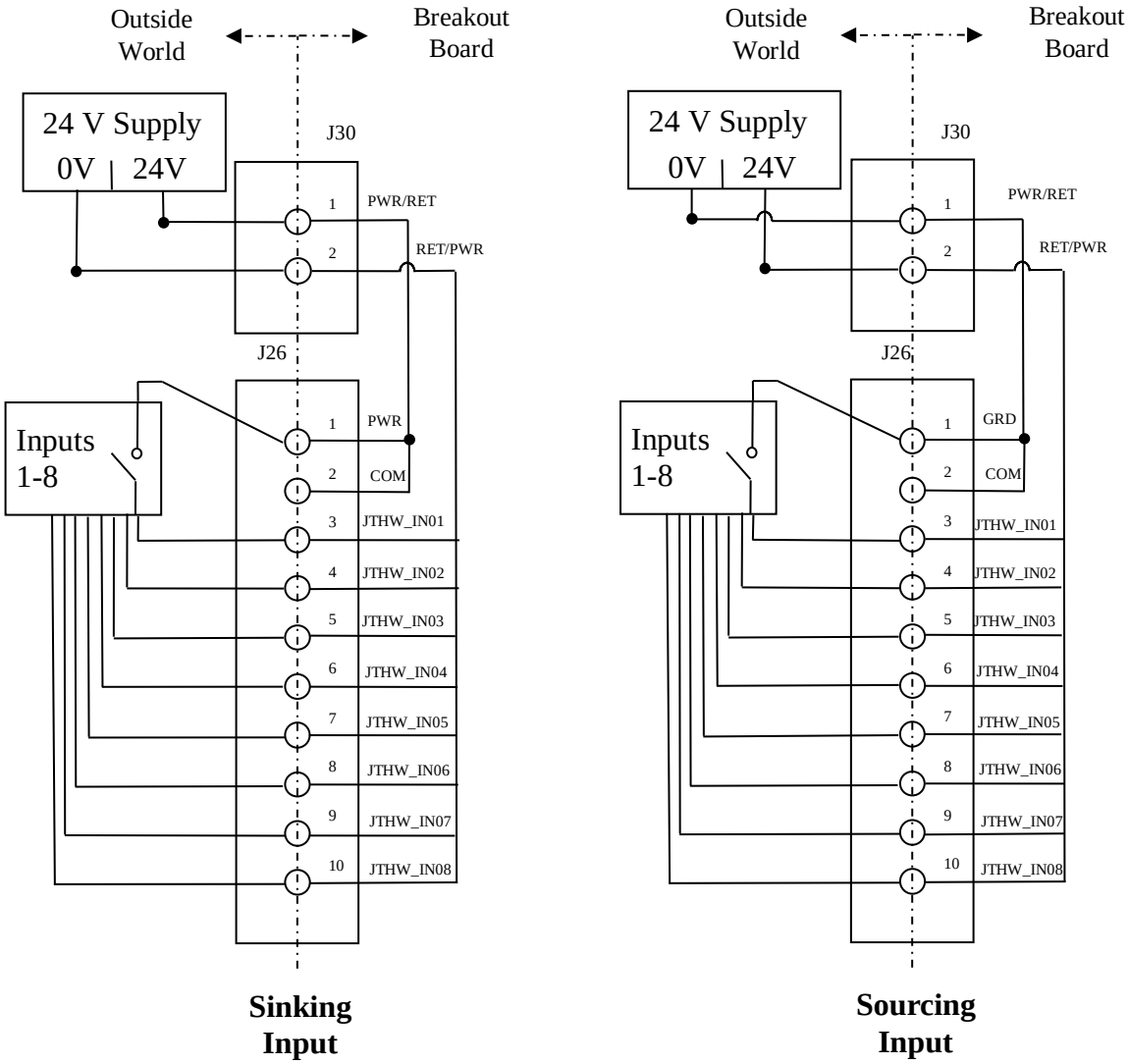
Pin #	Symbol	Function	Description
1	COM_COL_1	RTNFL	Tie to 24VDC (Sourcing)
2	COM_COL_1	RTNFL	Tie to 24VDC (Sourcing)
3	JTHW_OUT1-	Output	SEL0
4	JTHW_OUT2-	Output	SEL 1
5	JTHW_OUT3-	Output	SEL 2
6	JTHW_OUT4-	Output	SEL 3
7	JTHW_OUT5-	Output	SEL 4
8	JTHW_OUT6-	Output	SEL 5
9	JTHW_OUT7-	Output	SEL 6
10	N/A	N/A	N/A

Thumbwheel Port As Discrete I/Os, Suggested M-Variables

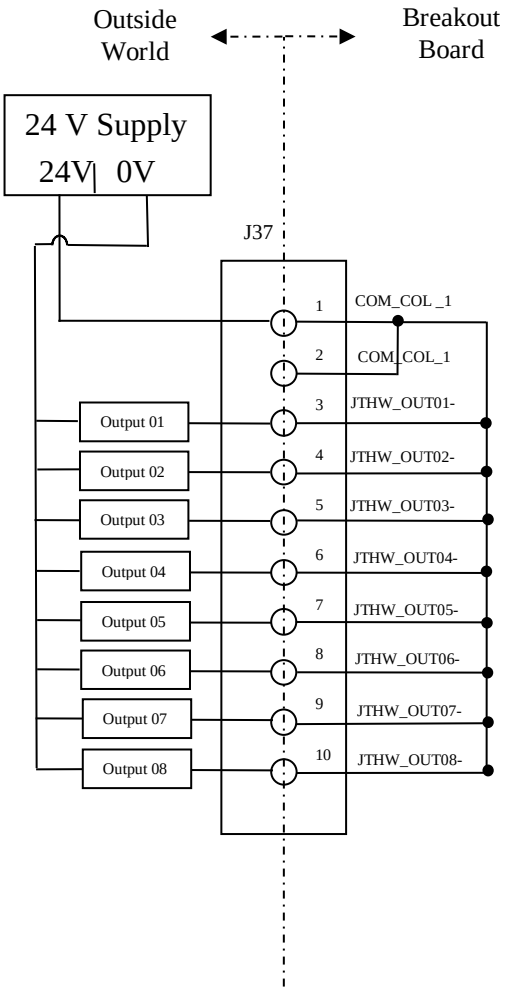
The inputs and outputs on the thumbwheel multiplexer port (J26-J27-J37) can be used as discrete, non-multiplexed general purpose I/Os, and accessed through M-Variable pointers:

```
M40->Y:$78402,8,1      ; SEL0 Output
M41->Y:$78402,9,1      ; SEL1 Output
M42->Y:$78402,10,1     ; SEL2 Output
M43->Y:$78402,11,1     ; SEL3 Output
M44->Y:$78402,12,1     ; SEL4 Output
M45->Y:$78402,13,1     ; SEL5 Output
M46->Y:$78402,14,1     ; SEL6 Output
M47->Y:$78402,15,1     ; SEL7 Output
M48->Y:$78402,8,8,U    ; SEL0-7 Outputs treated as a byte
M50->Y:$78402,0,1      ; DAT0 Input
M51->Y:$78402,1,1      ; DAT1 Input
M52->Y:$78402,2,1      ; DAT2 Input
M53->Y:$78402,3,1      ; DAT3 Input
M54->Y:$78402,4,1      ; DAT4 Input
M55->Y:$78402,5,1      ; DAT5 Input
M56->Y:$78402,6,1      ; DAT6 Input
M57->Y:$78402,7,1      ; DAT7 Input
M58->Y:$78402,0,8,U    ; DAT0-7 Inputs treated as a byte
```

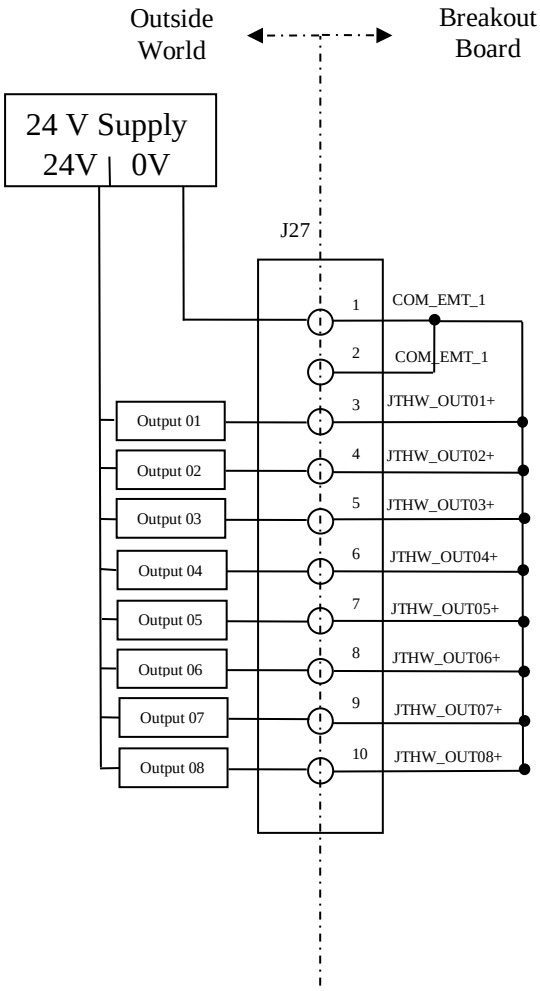
Wiring The Thumbwheel As Discrete I/Os



Sinking Input **Sourcing Input**

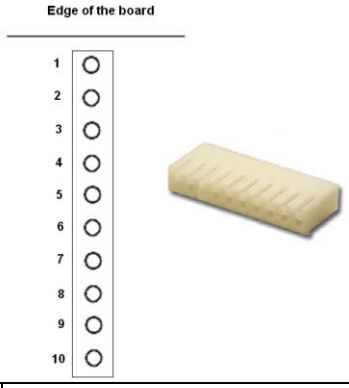


Sinking Output



Sourcing Output

J28: General Purpose Inputs

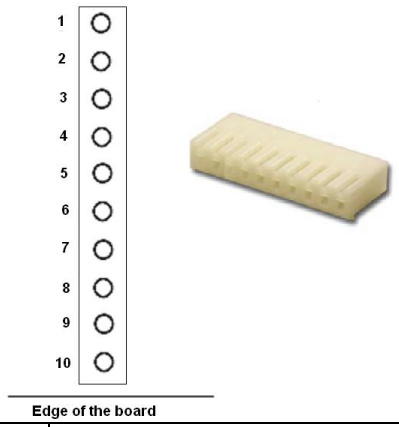
J28: Molex (M) **Molex Mating Connector pn#: 22-01-3107(F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000W10-LHM** **DT Part #: 025-500114-PNM**	

Pin #	Symbol	Function	Description
1	IN_PWR/RET	RTNFL	Return Flag (Tie to 0V or 24V)
2	IN_COM_2	RTNFL	Return Flag (Tie to 0V or 24V)
3	JOPT_IN01	Input	Input 1
4	JOPT_IN02	Input	Input 2
5	JOPT_IN03	Input	Input 3
6	JOPT_IN04	Input	Input 4
7	JOPT_IN05	Input	Input 5
8	JOPT_IN06	Input	Input 6
9	JOPT_IN07	Input	Input 7
10	JOPT_IN08	Input	Input 8

J29: General Purpose Outputs (sinking)

J29: Molex (M)
Molex Mating Connector pn#: 22-01-3107 (F)
Molex Crimper Pin Part #: 08-50-0114

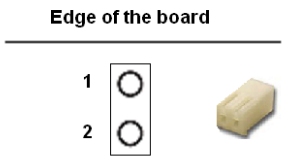
For Internal Use:
DT Part #: 014-000W10-LHM
DT Part #: 025-500114-PNM



Pin #	Symbol	Function	Description
1	COM_EMT_2	RTNFL	Tie to Common 0V (Sinking)
2	COM_EMT_2	RTNFL	Tie to Common 0V (Sinking)
3	JOPT_OUT1+	Output	Output 1 +
4	JOPT_OUT2+	Output	Output 2 +
5	JOPT_OUT3+	Output	Output 3 +
6	JOPT_OUT4+	Output	Output 4 +
7	JOPT_OUT5+	Output	Output 5 +
8	JOPT_OUT6+	Output	Output 6 +
9	JOPT_OUT7+	Output	Output 7 +
10	JOPT_OUT8+	Output	Output 8 +

J30: General Purpose I/O Power

The general purpose I/O(s) wiring is user configurable; it can be either sinking or sourcing.

J30: Molex (M) **Molex Mating Connector Part #:: 22-01-3027 (F)** **Molex Crimper Pin Part #: 08-50-0114** **For Internal Use:** **DT Part #: 014-000R02-LHM** **DT Part #: 025-500114-PNM**	

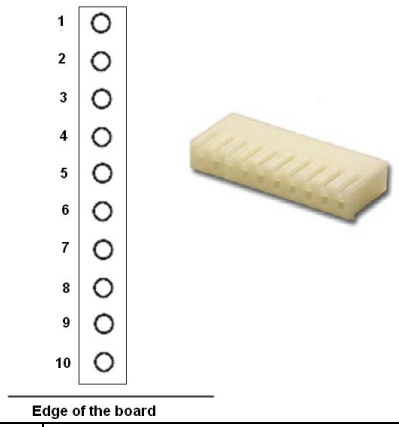
Sinking Configuration			
Pin #	**Symbol**	**Function**	**Description**
1	12~24VDC IN_PWR	Input	Flag Power (+24VDC)
2	12~24VDC IN_RET	Input	Flag Return (Common)

Sourcing Configuration			
Pin #	**Symbol**	**Function**	**Description**
1	12~24VDC IN_RET	Input	Flag Return (Common)
2	12~24VDC IN_PWR	Input	Flag Power (+24VDC)

J38: General Purpose Outputs (sourcing)

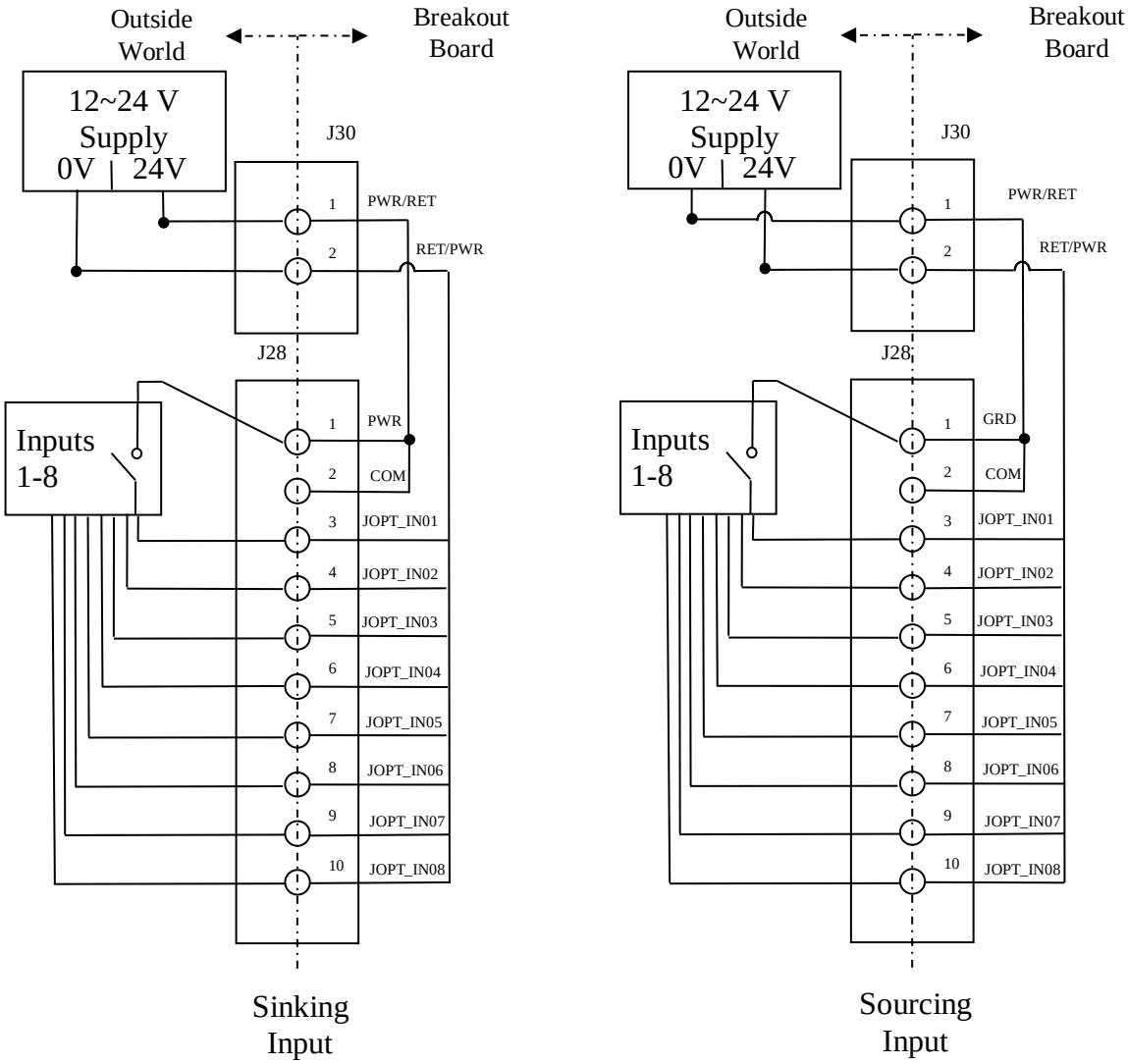
J38: Molex (M)
Molex Mating Connector pn#: 22-01-3107(F)
Molex Crimper Pin Part #: 08-50-0114

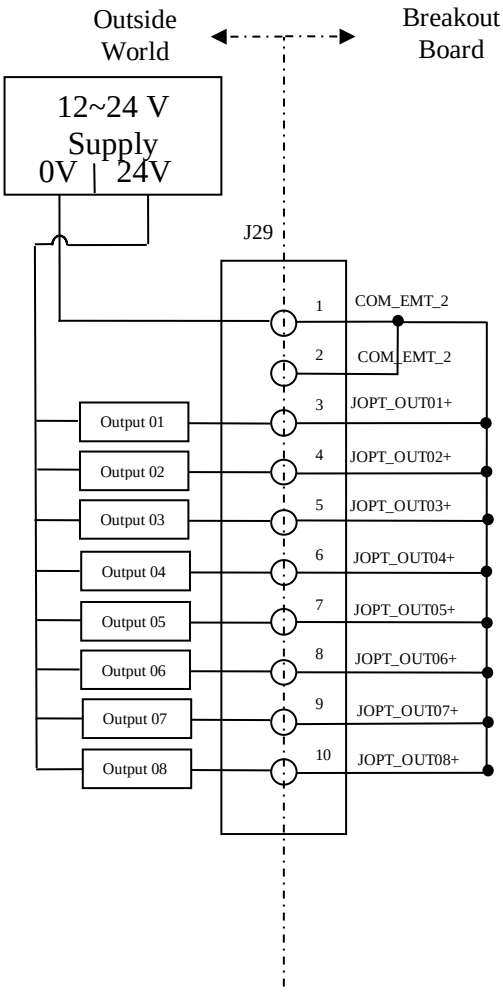
For Internal Use:
DT Part #: 014-000W10-LHM
DT Part #: 025-500114-PNM



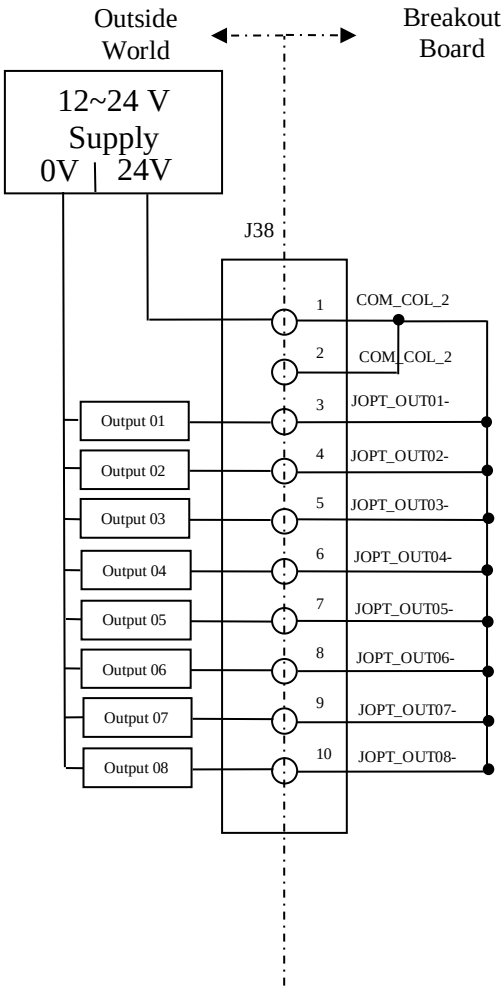
Pin#	Symbol	Function	Description
1	COM_COL_2	RTNFL	Tie to 24VDC (Sourcing)
2	COM_COL _2	RTNFL	Tie to 24VDC (Sourcing)
3	JOPT_OUT1-	Output	Output 1 -
4	JOPT_OUT2-	Output	Output 2 -
5	JOPT_OUT3-	Output	Output 3 -
6	JOPT_OUT4-	Output	Output 4 -
7	JOPT_OUT5-	Output	Output 5 -
8	JOPT_OUT6-	Output	Output 6 -
9	JOPT_OUT7-	Output	Output 7 -
10	JOPT_OUT8-	Output	Output 8 -

Wiring the General Purpose I/Os





Sinking Output



Sourcing Output

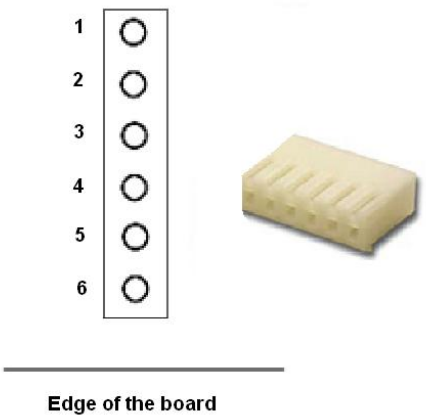
General Purpose I/Os, Suggested M-Variables

```
M1->Y:$78400,0          ; Digital Output 1
M2->Y:$78400,1          ; Digital Output 2
M3->Y:$78400,2          ; Digital Output 3
M4->Y:$78400,3          ; Digital Output 4
M5->Y:$78400,4          ; Digital Output 5
M6->Y:$78400,5          ; Digital Output 6
M7->Y:$78400,6          ; Digital Output 7
M8->Y:$78400,7          ; Digital Output 8

M9->Y:$78400,8          ; Digital Input 1
M10->Y:$78400,9         ; Digital Input 2
M11->Y:$78400,10        ; Digital Input 3
M12->Y:$78400,11        ; Digital Input 4
M13->Y:$78400,12        ; Digital Input 5
M14->Y:$78400,13        ; Digital Input 6
M15->Y:$78400,14        ; Digital Input 7
M16->Y:$78400,15        ; Digital Input 8

M32->X:$78400,0,8       ; Direction Control bits 0-7 (1=output, 0 = input)
M34->X:$78400,8,8       ; Direction Control bits 8-15 (1=output, 0 = input)
M40->X:$78404,0,24      ; Inversion control (0 = 0V, 1 = 5V)
M42->Y:$78404,0,24      ; J9 port data type control (1 = I/O)

//In order to properly setup the digital I/Os, an initialization PLC must be written scanning
//through once on power-up/reset, setting control statuses then disabling itself:

Open PLC 1 clear
M32=$FF                 ; BITS 0-7 are assigned as output
M34=$0                  ; BITS 8-15 are assigned as input
M40=$FF00               ; Define inputs and outputs
M42=$FFFF               ; All lines are I/O type
DIS PLC1                ; Disable PLC1 (scanning through once on power-up/reset)
Close
```

J31-J32: Handwheel Port(s)

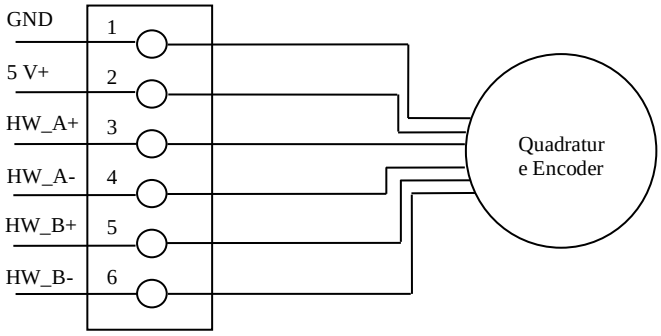
J31-J32: Molex (M)
Molex Mating Connector Part #: 22-01-3067 (F)
Molex Crimper Pin Part #: 08-50-0114

For Internal Use:
DT Part #: 014-000R06-LHM
DT Part #: 025-500114-PNM



Pin #	Symbol	Function	Description
1	DGND	Common	Ground
2	+5V	Output	5 Volts
3	HW_A+	Input	Handwheel Quadrature A
4	HW_A-	Input	Handwheel Quadrature A/
5	HW _B+	Input	Handwheel Quadrature B
6	HW_B-	Input	Handwheel Quadrature B/

A quadrature encoder type device is normally brought in to the handwheel port; it can be wired in either single-ended or differential mode. The ground has to be tied to the connectors' ground, especially in single-ended applications.



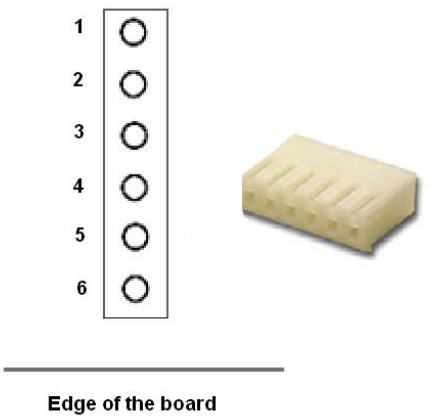
The encoder data can be exported to the Encoder Conversion Table allowing direct access with an M-variable or used as a master position for a specific motor (Ixx05). Example:

```
I8000=$78410           ; Entry 1: 1/T extension of location $78410 MACRO IC 1
M8010->X:$3501,0,24,S  ; ECT 1st entry result
I8001=$78418           ; Entry 2: 1/T extension of location $78418 MACRO IC 2
M8011->X:$3502,0,24,S  ; ECT 2nd entry result
```

J33-J34: Pulse and Direction Output(s) (PFM)

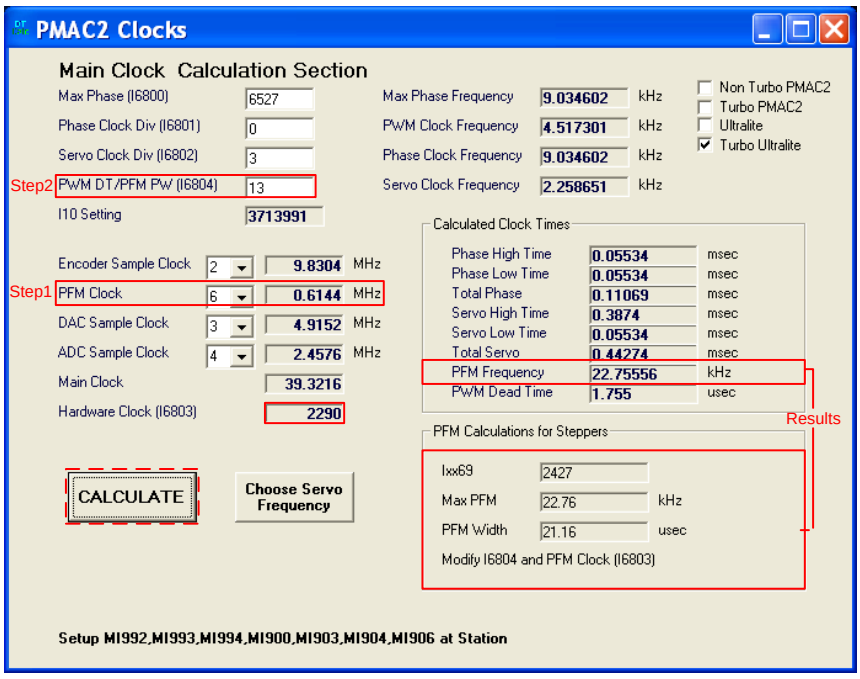
J33-J34: Molex (M)
Molex Mating Connector Part #: 22-01-3067 (F)
Molex Crimper Pin Part #: 08-50-0114

For Internal Use:
DT Part #: 014-000R06-LHM
DT Part #: 025-500114-PNM



Pin #	Symbol	Function	Description
1	DGND	Common	Ground
2	+5V	Output	5 Volts
3	PUL~+	Output	Pulse Plus
4	PUL~-	Output	Pulse Minus
5	DIR~+	Output	Direction Plus
6	DIR~-	Output	Direction Minus

The Turbo Clipper Drive offers two additional Step and Direction (Pulse Frequency Modulation) outputs, using the supplementary channels. These signals can be connected in either differential or single-ended configuration for 5V input drives. Using the Delta Tau Calculator or referring to the Turbo Software Reference Manual, the desired maximum PFM Frequency and pulse width can be chosen. **DT Calculator Link**


PMAC2 Clocks
Main Clock Calculation Section
Max Phase (I6800) 6527
Phase Clock Div (I6801) 0
Servo Clock Div (I6802) 3
Step2 PWM DT/PFM PW (I6804) 13
I10 Setting 3713991
Encoder Sample Clock 2 9.8304 MHz
Step1 PFM Clock 6 0.6144 MHz
DAC Sample Clock 3 4.9152 MHz
ADC Sample Clock 4 2.4576 MHz
Main Clock 39.3216
Hardware Clock (I6803) 2290
CALCULATE
Choose Servo Frequency
Max Phase Frequency 9.034602 kHz
PWM Clock Frequency 4.517301 kHz
Phase Clock Frequency 9.034602 kHz
Servo Clock Frequency 2.258651 kHz
Non Turbo PMAC2
Turbo PMAC2
Ultralite
Turbo Ultralite
Calculated Clock Times
Phase High Time 0.05534 msec
Phase Low Time 0.05534 msec
Total Phase 0.11069 msec
Servo High Time 0.3874 msec
Servo Low Time 0.05534 msec
Total Servo 0.44274 msec
PFM Frequency 22.75556 kHz
PWM Dead Time 1.755 usec
Results
PFM Calculations for Steppers
Ixx69 2427
Max PFM 22.76 kHz
PFM Width 21.16 usec
Modify I6804 and PFM Clock (I6803)
Setup MI992,MI993,MI994,MI900,MI903,MI904,MI906 at Station

Step1 : Choose Max PFM clock by changing the PFM clock divider in the calculator
Step2 : Choose PFM Pulse Width by changing I7m04 in the calculator

For a PFM clock range 0-20 KHz, and a pulse width of ~20 μsec:

```
I6803=2290              ; PFM Clock divider equal to 6
I6804=13                ; PFM Pulse Width Control equal to 13
```

The output frequency control Ixx69 specifies the maximum command output value that corresponds to the maximum PFM Frequency.

```
I6826=3                 ; MACRO IC0 Channel2 Output Mode Select. C PFM
M8000->Y:$7841C,8,16,S ; Supplementary Channel 2* Output C Command Value
                        ; Min=0, Max= Calculated Ixx69
```

Testing The PFM Output

Writing, directly to the suggested M-variable (i.e. M8000), values proportional to Ixx69 produces corresponding frequencies:

M8000	PFM [KHz]
0	0
1213	11
2427	22

Example:

Axis 5-6 to drive stepper amps, w/ PFM clock range 0-20 KHz and pulse width of ~20 μsec:

```
I6803=2290              ; PFM Clock divider equal to 6
I6804=13                ; PFM Pulse Width Control equal to 13
// Supplementary Channel 1, and 2 Settings:
I6816,2,10=3            ; Supp. channel 1-2 output mode, PFM
I6810,2,10=8            ; Supp. channel 1-2 Encoder Decode, Internal Pulse and Direction
I500,2,100=1            ; Motors 5,6 active
I511,2,100=0            ; Motors 5,6 disable fatal following error

I502=$78414             ; Motor #5 output to point to output c for PFM
I8004=$C78410           ; Encoder Conversion table to read, C for no extension
I503=$3505
I504=$3505
I524=$120001            ; Disable amp fault and overtravel limits
I525=$78410             ;

I602=$7841C             ; #2 output to point to output c for PFM
I8005=$C78418           ; Encoder Conversion table to read, C for no extension
I603=$3506
I604=$3506
I624=$120001            ; Disable amp fault and over travel limit
I625=$78418
```

The position-Loop PID Gains are calculated using the following equations:

Ixx30=660000/Ixx08*PFM Clock[MHz]

Ixx31=0

Ixx32 = 6660* ServoFreq(kHz)

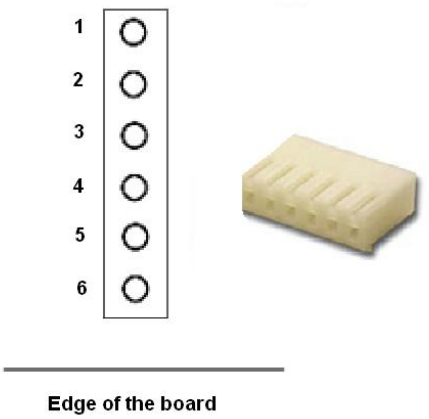
Ixx33...Ixx35=0

```
// Position-Loop PID Gains:
I530,2,100=11190        ; Motors 5-6 Proportional Gain
I531,2,100=0            ; Motors 5-6 Derivative Gain
I532,2,100=151515       ; Motors 5-6 Velocity FeedForward Gain
I533,2,100=0            ; Motors 5-6 Integral Gain
I534,2,100=0            ; Motors 5-6 Integral Mode
I535,2,100=0            ; Motors 5-6 Acceleration FeedForward Gain
```

J35: Programmable Output

J35: Molex (M)
Molex Mating Connector Part #: 22-01-3067 (F)
Molex Crimper Pin Part #: 08-50-0114

For Internal Use:
DT Part #: 014-000R06-LHM
DT Part #: 025-500114-PNM



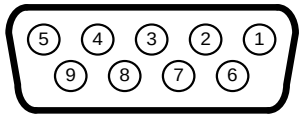
Pin #	Symbol	Function	Description
1	DGND	Common	Ground
2	+5V	Output	5 Volts
3	PGOUT0+	Output	Programmable output 0+
4	PGOUT0-	Output	Programmable output 0-
5	PGOUT1+	Output	Programmable output 1+
6	PGOUT1-	Output	Programmable output 1-

Clipper's Option 11 consists of a programmable lattice chip which can be programmed based upon customer's requirements for laser control. Refer to Turbo Clipper Hardware Reference Manual for more descriptions.

External Amp 1-4:

If the power board is attached to the assembly, these connectors are not used in most cases. A good usage for them is driving a high power motor with a 3rd party amplifier in either pulse and direction (PFM) or Filtered PWM (DAC) mode.

If the power board is not attached to the stack, these connectors serve as the traditional connection to the drive(s) and are set up as any Turbo PMAC2 for pulse and direction (PFM) or Filtered PWM (DAC) output.

External Amp 1-4: D-Sub DE-9F Mating: D-Sub DE-9M			
Pin#	**Symbol**	**Function**	**Description**
1	GND	Common	Ground
2	DAC-	Output	DAC Output -
3	GND	Common	Ground
4	DIR+	Output	Direction Plus Output
5	FALT-	Input	Amp Fault
6	DAC+	Output	DAC Output+
7	+5V_5A	Output	5 volts Output
8	PUL+	Output	Pulse Plus Output
9	AENA-	Output	Amp Enable

Pulse and direction Setup Example, channels 1-4:

```
I100,4,100=1                ; Motor 1-4 activation
I7016,4,10=3                ; Servo IC 0 Channel 1-4 output mode, PFM
I7010,4,10=8                ; Servo IC 0 Channel 1-4 Encoder Decode
                            ; Internal pulse and direction
I102=$78004                 ; Mtr1 output to point to channel 1 output c for PFM
I202=$7800c                 ; Mtr2 output to point to channel 2 output c for PFM
I302=$78014                 ; Mtr3 output to point to channel 3 output c for PFM
I402=$7801C                 ; Mtr4 output to point to channel 4 output c for PFM
I8000=$C78000               ; C for Incremental Encoder, mode switch = no extension
I8001=$C78008               ; C for Incremental Encoder, mode switch = no extension
I8002=$C78010               ; C for Incremental Encoder, mode switch = no extension
I8003=$C78018               ; C for Incremental Encoder, mode switch = no extension
I103,2,1=$3501              ;
I203,2,1=$3502              ;
I303,2,1=$3503              ;
I403,2,1=$3504              ;

I124,4,100=$120001          ; Disable amp fault and overtravel limits
I125=$78000                 ;
I225=$78008                 ;
I325=$78010                 ;
I425=$78018                 ;
I111,4,100=0                ; Disable fatal following error
```

Filtered PWM (DAC) output Example, channels 1-4:

```
I7000= 981                          ; PWM frequency ~30kHz
I7001= 5                            ; Phase Clock ~10kHz
I7002= 3                            ; Servo frequency ~2.5Hz
I7016,4,10= 0                       ; Output Mode PWM
I169,4,100= 981                     ; DAC limit 10Vdc
I102 =$078002                       ;
M8000->Y:$78002,8,16,S              ; Servo IC 0 ch1 Output A Command Value Min=0, Max= I169
I202=$07800A                        ;
M8000->Y:$7800A,8,16,S              ; Servo IC 0 ch2 Output A Command Value Min=0, Max= I269
I302=$078012                        ;
M8000->Y:$78012,8,16,S              ; Servo IC 0 ch3 Output A Command Value Min=0, Max= I369
I202=$07801A                        ;
M8000->Y:$7801A,8,16,S              ; Servo IC 0 ch4 Output A Command Value Min=0, Max= I469
```

CLIPPER BOARD: WIRING, SOFTWARE SETUP

USB 2.0 Connector

This connector uses a USB A-B cable to establish communication between the PC and the Turbo Clipper Drive Drive. This type of USB cable could be purchased at any local electronics or computer store. It may be ordered from Delta Tau as well.

Pin #	Symbol	Function
1	VCC	N.C.
2	D-	Data-
3	D+	Data+
4	Gnd	GND
5	Shell	Shield
6	Shell	Shield

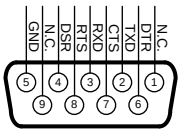
RJ45, Ethernet Connector

This connector is used to establish communication over Ethernet between the PC and the Turbo Clipper Drive Drive. A crossover cable is required if you are going directly to the Clipper board from the PC Ethernet card, and not through a hub.

Delta Tau strongly recommends the use of RJ45 CAT5e or better shielded cable. Newer network cards have the Auto-MDIX feature that eliminates the need for crossover cabling by performing an internal crossover when a straight cable is detected during the auto-negotiation process. For older network cards, one end of the link must perform media dependent interface (MDI) crossover (MDIX), so that the transmitter on one end of the data link is connected to the receiver on the other end of the data link (a crossover/patch cable is typically used). If an RJ45 hub is used, then a regular straight cable must be implemented. Maximum length for Ethernet cable should not exceed 100m (330ft).

RS232: Serial Communication Port

An optional serial RS-232 communication port is available on the Turbo Clipper Drive drives. This port can be used as a primary communication mean or employed as a secondary port that allows simultaneous communication.

RS-232: D-sub DE-9F Mating: D-Sub DE-9M				
Pin#	**Symbol**	**Function**	**Description**	**Notes**
1	N.C.		NC	
2	TXD	Output	Receive data	Host transmit Data
3	RXD	Input	Send data	Host receive Data
4	DSR	Bi-directional	Data set ready	Tied to “DTR”
5	GND	Common	Common GND	
6	DTR	Bi-directional	Data term ready	Tied to “DSR”
7	CTS	Input	Clear to send	Host ready bit
8	RTS	Output	Req. to send	PMAC ready bit
9	N.C		NC	

The baud rate for the RS-232 serial port is set by variable I54. At power-up reset, The Turbo Clipper Drive sets the active baud based on the setting of I54 and the CPU speed I52. Note that the baud rate frequency is divided down from the CPU’s operational frequency. The factory default baud rate is 38400. This baud rate will be selected automatically on re-initialization of the Turbo Clipper Drive, either in hardware using the re-initialization (RESET SW) button or in software using the **$$$***** command.

To change the baud rate setting on the Turbo Clipper Drive Drive, set I54 to the corresponding value of desired frequency. Issue a **SAVE** and recycle power on the unit. For odd baud rate settings, refer to the Turbo Software Reference Manual.

I54	**Baud Rate**	**I54**	**Baud Rate**
8	9600	*12	38,400
9	14,400	13	57,600
10	19,200	14	76,800
11	28,800	15	115,200

*Default Setting

MOTOR TYPE & PROTECTION POWER-ON PLCS

The current firmware version of the Turbo Clipper Drive requires motor mode setup, and clearing faults (local protection setup) on power-up. These tasks can be combined in a single PLC to execute once on power-up. The motor mode setup tells the firmware what type of motor (i.e. brush, brushless, stepper) is connected to which channel. Clearing faults (local protection setup) can be done by re-enabling the PLC whenever needed.

Note

The Geo Brick LV Setup Software generates this PLC automatically as you select and setup motors. Choosing "save settings" before exiting the setup window will save the PLC to the Turbo Clipper Drive.

Stepper Motor Power-On PLC

```
End Gat                ; End gather
Del Gat                ; Delete gather data
Close                  ; Close (any) open buffer
I5=I5|2                ; Allow background PLCs to execute
Open plc 1 clear       ; Open buffer
Disable PLCC 0..31     ; Disable all Compiled PLCs
Disable plc 0          ; Disable Foreground PLC
Disable plc  2..31     ; Disable all other Background PLCs
I5111=1000*8388608/I10 While (I5111>0) Endw  ; 1 sec Delay
CMD"wx$78014,$F8CDFE"  ; Axis1 Clear Fault (Stepper)
CMD"wx$78014,$F84DFE"  ; Axis1 Local protection & type (Stepper)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$F9CDFE"  ; Axis2 Clear Fault (Stepper)
CMD"wx$78014,$F94DFE"  ; Axis2 Local protection & type (Stepper)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$FACDFE"  ; Axis3 Clear Fault (Stepper)
CMD"wx$78014,$FA4DFE"  ; Axis3 Local protection & type (Stepper)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$FBCDFE"  ; Axis4 Clear Fault (Stepper)
CMD"wx$78014,$FB4DFE"  ; Axis4 Local protection & type (Stepper)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
Enable plc 2..31       ; Re-enable all other Background PLCs
Enable plc 0           ; Re-enable Foreground PLC
Enable plcc 0..31      ; Re-enable Compiled PLCs
Disable plc 1          ; Disable PLC1
Close                  ; close currently open buffer
```

Brushless/Brush Motor Power-On PLC

```
End Gat                ; End gather
Del Gat                ; Delete gather data
Close                  ; Close (any) open buffer
I5=I5|2                ; Allow background PLCs to execute
Open plc 1 clear       ; Open buffer
Disable PLCC 0..31     ; Disable all Compiled PLCs
Disable plc 0          ; Disable Foreground PLC
Disable plc  2..31     ; Disable all other Background PLCs
I5111=1000*8388608/I10 While (I5111>0) Endw  ; 1 sec Delay
CMD"wx$78014,$F8CCFE"  ; Axis1 Clear Fault (brushless/brush)
CMD"wx$78014,$F84CFE"  ; Axis1 Local protection & type (brushless/brush)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$F9CCFE"  ; Axis2 Clear Fault (brushless/brush)
CMD"wx$78014,$F94CFE"  ; Axis2 Local protection & type (brushless/brush)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$FACCFE"  ; Axis3 Clear Fault (brushless/brush)
CMD"wx$78014,$FA4CFE"  ; Axis3 Local protection & type (brushless/brush)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$FBCCFE"  ; Axis4 Clear Fault (brushless/brush)
CMD"wx$78014,$FB4CFE"  ; Axis4 Local protection & type (brushless/brush)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
Enable plc 2..31       ; Re-enable all other Background PLCs
Enable plc 0           ; Re-enable Foreground PLC
Enable plcc 0..31      ; Re-enable Compiled PLCs
Disable plc 1          ; Disable PLC1
Close                  ; Close currently open buffer
```

Note

It is possible to mix and match motor types by choosing the corresponding axis motor type setup and local protection in the power-on PLC. See example below.

Hybrid Motor Power-On PLC Example

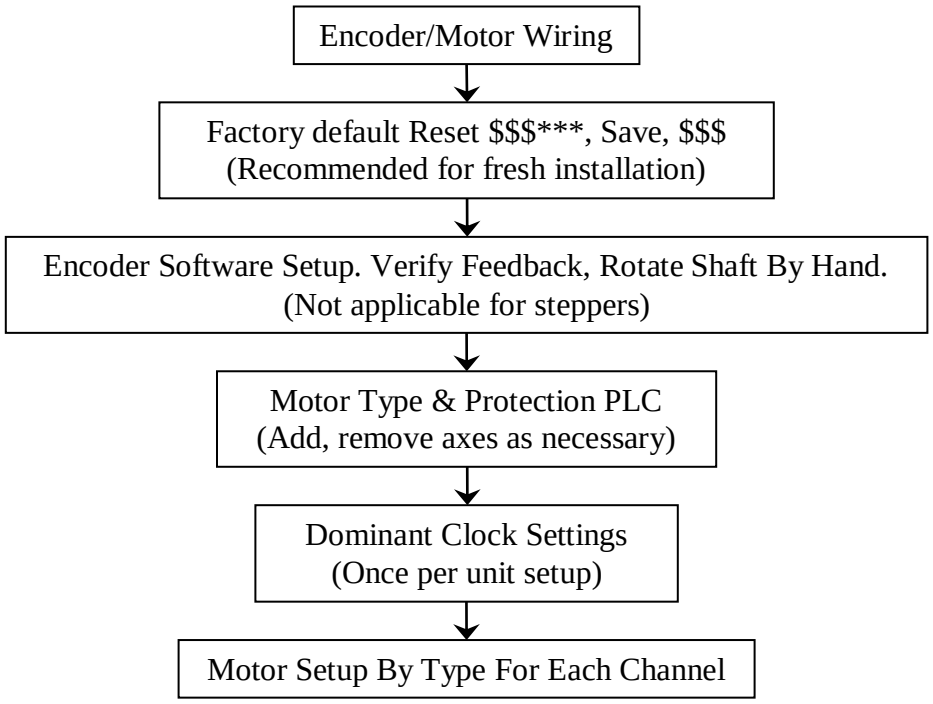
A Clipper Drive has 2 steppers on axes 1 and 2, two brushless or brush motors on axes 3 and 4;

```
End Gat                ; End gather
Del Gat                ; Delete gather data
Close                  ; Close (any) open buffer
I5=I5|2                ; Allow background PLCs to execute

Open plc 1 clear       ; Open buffer
Disable PLCC 0..31     ; Disable all Compiled PLCs
Disable plc 0          ; Disable Foreground PLC
Disable plc  2..31     ; Disable all other Background PLCs
I5111=1000*8388608/I10 While (I5111>0) Endw  ; 1 sec Delay
CMD"wx$78014,$F8CDFE"  ; Axis1 Clear Fault (Stepper)
CMD"wx$78014,$F84DFE"  ; Axis1 Local protection & type (Stepper)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$F9CDFE"  ; Axis2 Clear Fault (Stepper)
CMD"wx$78014,$F94DFE"  ; Axis2 Local protection & type (Stepper)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$FACCFE"  ; Axis3 Clear Fault (brushless/brush)
CMD"wx$78014,$FA4CFE"  ; Axis3 Local protection & type (brushless/brush)
I5111=100*8388608/I10 While (I5111>0) Endw   ; 100 msec Delay
CMD"wx$78014,$FBCCFE"  ; Axis4 Clear Fault (brushless/brush)
CMD"wx$78014,$FB4CFE"  ; Axis4 Local protection & type (brushless/brush)
Enable plc 2..31       ; Re-enable all other Background PLCs
Enable plc 0           ; Re-enable Foreground PLC
Enable plcc 0..31      ; Re-enable Compiled PLCs
Disable plc 1          ; Disable PLC1
Close                  ; Close currently open buffer
```

MOTOR SETUP GUIDELINES

This section provides with manual (step by step) motor setup guidelines for stepper, DC brushless, and brush motors. This motor setup segment should be the last of a few necessary steps to properly configure a motor with Turbo Clipper Drive drives.

Motor Setup Flow Chart


Encoder/Motor Wiring
Factory default Reset $$$***, Save, $$$
(Recommended for fresh installation)
Encoder Software Setup. Verify Feedback, Rotate Shaft By Hand.
(Not applicable for steppers)
Motor Type & Protection PLC
(Add, remove axes as necessary)
Dominant Clock Settings
(Once per unit setup)
Motor Setup By Type For Each Channel

Note For encoder-driven motors (none steppers), this section assumes that feedback device(s) have been setup properly, and that moving the motor/encoder shaft by hand shows correct data in the position window.

Dominant Clock Settings

The choice of clock settings usually relies on system requirements, and type of application.

Calculating Minimum PWM Frequency

The minimum PWM frequency of a system is based on the time constant of the motor. In general, the lower the time constant, the higher the PWM frequency should be. The motor time constant is calculated dividing the motor inductance by the resistance (phase-phase). The minimum PWM Frequency is then determined using the following relationship:

$$\tau_{sec} = \frac{L_H}{R_{Ohms}} \qquad \tau > \frac{20}{2\pi \times PWM} \Rightarrow PWM\,(Hz) > \frac{20}{2\pi\tau_{sec}}$$

Example: A motor with an inductance of 2.80 mH, resistance of 14 Ω (phase-phase) yields a time constant of 0.200 milliseconds. Therefore, the minimum PWM Frequency is ~15.9KHz.

The most commonly used and recommended clock settings for Turbo Clipper Drive drives are 20 KHz PWM, 10 KHz Phase, and 5 KHz Servo:

```
I7000=1473      ; Servo IC0 Max Phase/PWM Frequency Control
I7001=3         ; Servo IC0 Phase Clock Frequency Control
I7002=1         ; Servo IC0 Servo Clock Frequency Control

I10=1677653     ; Servo Interrupt Time
```

Clock Calculations

These clock calculations are used in and imperative for subsequent section(s) in selected downloadable Turbo PMAC scripts. Whether default, recommended, or custom clock settings are chosen, these calculations should be downloaded and saved.

```
I15=0                          ; Trigonometric calculation in degrees
#define MaxPhaseFreq   P7000   ; Max Phase Clock [KHz]
#define PWMClk         P7001   ; PWM Clock [KHz]
#define PhaseClk       P7002   ; Phase Clock [KHz]
#define ServoClk       P7003   ; Servo Clock [KHz]

MaxPhaseFreq=117964.8/(2*I7000+3)
PWMClk=117964.8/(4*I7000+6)
PhaseClk=MaxPhaseFreq/(I7001+1)
ServoClk=PhaseClk/(I7002+1)
```

Setting Up Stepper Motor, Direct Micro-Stepping

Before you start

- It is always recommended to start a fresh setup from factory default settings, $$$*** followed by a Save and a $$$.
- Don't forget to create/edit the motor type and protection power-on PLC.
- Parameters with Comments ending with **-User Input** require the user to enter information pertaining to their system/hardware.
- Downloading and using the suggested M-variables is highly recommended.
- Detailed description of motor setup parameters can be found in the Turbo SRM Manual Turbo SRM Link

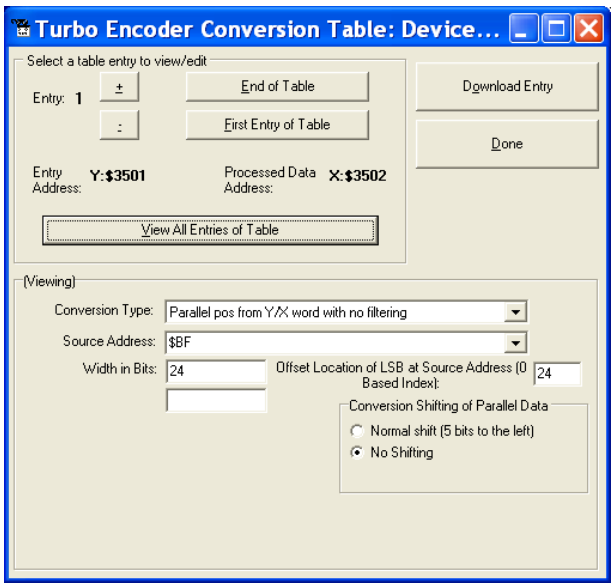
The traditional direct-microstepping technique controlled with sinusoidal outputs from the Turbo PMAC is not appropriate for motors controlled with direct-PWM outputs such as in Turbo Clipper Drive Drives. A new technique permits direct microstepping along with direct-PWM motor control.

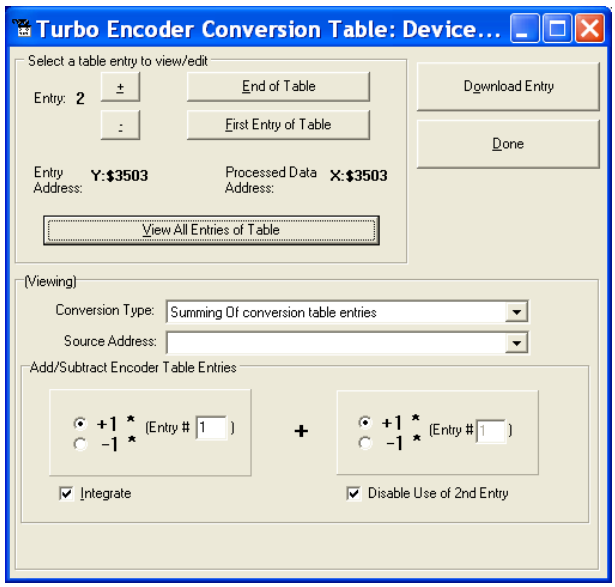
This technique creates a simulated position sensor and feedback loop by numerically integrating the (velocity) command output from the servo loop. This integration requires two entries in the encoder conversion table. The resulting simulated position value can be used for both motor phase commutation and servo-loop feedback. Alternately, a load encoder could be used for position-loop feedback while this simulated value is used for commutation.

Encoder Conversion Table Setup

The first entry in the encoder conversion table (ECT) for each stepper motor must read the servo-loop output like an absolute encoder. This is done with a "parallel-read" entry of a Y/X double register (the data is in X), unshifted and unfiltered; specifying the use of 24 bits of the 48-bit Y/X register, starting 24 bits from the low end. This is effectively like reading a 24-bit DAC register.

The second entry in the ECT for each stepper motor integrates the result of the first entry.


Turbo Encoder Conversion Table: Device...
Select a table entry to view/edit
Entry: 1
End of Table
First Entry of Table
Download Entry
Done
Entry Address: Y:$3501
Processed Data Address: X:$3502
View All Entries of Table
(Viewing)
Conversion Type: Parallel pos from Y/X word with no filtering
Source Address: $BF
Width in Bits: 24
Offset Location of LSB at Source Address (0 Based Index): 24
Conversion Shifting of Parallel Data
Normal shift (5 bits to the left)
No Shifting



Motor (Quadrature/torque) command value Registers

Motor #	Address (X-Memory)
1	$0000BF
2	$00013F
3	$0001BF
4	$00023F

Motors 1-4 Stepper Setup Encoder Conversion Table

```
I8000=$6800BF  ; Parallel read of Y/X:$BF
I8001=$18018   ; Use 24 bits starting at X bit 0
I8002=$EC0001  ; Integrate result from I8001
I8003=$68013F  ; Parallel read of Y/X:$13F
I8004=$18018   ; Use 24 bits starting at X bit 0
I8005=$EC0004  ; Integrate result from I8004
I8006=$6801BF  ; Parallel read of Y/X:$1BF
I8007=$18018   ; Use 24 bits starting at X bit 0
I8008=$EC0007  ; Integrate result from I8007
I8009=$68023F  ; Parallel read of Y/X:$23F
I8010=$18018   ; Use 24 bits starting at X bit 0
I8011=$EC000A  ; Integrate result from I8010
```

Position, Velocity Pointers: Ixx03, Ixx04

The position and velocity pointers (no external encoder used) will be set to the integration result:

```
I103=$3503     I104=$3503     ; Motor 1 position and velocity feedback
I203=$3506     I204=$3506     ; Motor 2 position and velocity feedback
I303=$3509     I304=$3509     ; Motor 3 position and velocity feedback
I403=$350C     I404=$350C     ; Motor 4 position and velocity feedback
```

Motor Activation, Commutation Enable: Ixx00, Ixx01

```
I100,4,100=1   ; Motors 1-4 active
I101,4,100=1   ; Motors 1-4 Commutation Enabled
```

Command Output Address: Ixx02

```
I102=$078002           ; Motor 1 Output Address
I202=$07800A           ; Motor 2 Output Address
I302=$078012           ; Motor 3 Output Address
I402=$07801A           ; Motor 4 Output Address
```

Current Feedback, ADC Mask, Commutation angle: Ixx82, Ixx84, Ixx72

```
I182=$078006           ; Motor 1 Current Feedback Address
I282=$07800E           ; Motor 2 Current Feedback Address
I382=$078016           ; Motor 3 Current Feedback Address
I482=$07801E           ; Motor 4 Current Feedback Address
I184,4,100=$FFFC00     ; Motors 1-4 Current Loop Feedback Mask, 14-bit
I172,4,100=512         ; Mtrs 1-4 Commutation Phase Angle.2-Phase opposite voltage & current sign
```

Flag Address, Mode Control: Ixx25, Ixx24

```
I125=$078000            ; Motor 1 Flag Address
I225=$078008            ; Motor 2 Flag Address
I325=$078010            ; Motor 3 Flag Address
I425=$078018            ; Motor 4 Flag Address
I124=$800401            ; Motor 1 Flag Control. High True Amp Fault, disable 3rd Harmonic
I224=$800401            ; Motor 2 Flag Control. High True Amp Fault, disable 3rd Harmonic
I324=$800401            ; Motor 3 Flag Control. High True Amp Fault, disable 3rd Harmonic
I424=$800401            ; Motor 4 Flag Control. High True Amp Fault, disable 3rd Harmonic
```

Commutation Address, Cycle size: Ixx83, Ixx70, Ixx71

```
I183=$3503              ; Motor 1 on-going Commutation Address (ECT Integration Result)
I283=$3506              ; Motor 2 on-going Commutation Address (ECT Integration Result)
I383=$3509              ; Motor 3 on-going Commutation Address (ECT Integration Result)
I483=$350C              ; Motor 4 on-going Commutation Address (ECT Integration Result)
I170,4,100=1            ; Motors 1-4 Single cycle size
I171,4,100=65536        ; Microsteps per Ixx70 commutation cycles
```

Maximum Achievable Motor Speed, Output Command Limit: Ixx69

In Micro-Stepping, the maximum achievable speed is proportional to the Servo clock and Motor Step angle. A faster Servo Clock results in higher achievable motor speeds.

To ensure the safety of the application and reliability of the micro-stepping technique, the smaller value of the Theoretical versus Calculated output command limit Ixx69 must be chosen.

Theoretical Ixx69
Sine Table: 2048
Electrical Length = 2048*32 (5-bit shift) = 65536
Max Electrical Length per Servo Cycle = Electrical Length/6 = 10922.66667
Micro-Stepping Theoretical Ixx69 = Max Electrical Length per Servo Cycle/256 = 42.6667

Calculated Ixx69
Servo Clock (KHz): 8
Stepper Angle: 1.8°
Motor Speed (rpm): 1500
Electrical Cycles per Revolution = 360 / (4*Stepper Angle)
Maximum-Achievable Motor Speed (RPM) =
(Servo Clock*1000) / (Electrical Cycles per Revolution*6)*60
Calculated Ixx69 =
Max Motor Speed* Electrical Cycles per Revolution/ 60 * 2048/6/(Servo Clock *1000)

```
#define StepAngle              1.8     ; Step Angle [Degrees] -User Input
#define MotorSpeed             1500    ; Motor Speed Spec [RPM] -User Input
#define ElecCyclePerRev        P7004   ; Electrical Cycle Per Revolution
ElecCyclePerRev=360/(4* StepAngle)
#define MaxMtrSpeed            P7005   ; This is the maximum achievable motor speed
MaxMtrSpeed=( ServoClk*1000)/( ElecCyclePerRev*6)*60
#define CalculatedIxx69        P7006   ; Calculated Ixx69
CalculatedIxx69= MotorSpeed*ElecCyclePerRev/60*2048/6/(ServoClk*1000)
```

Setting up 1.8° Step Motors specified at 1500 rpm and a Servo Clock of 8 KHz results in a maximum achievable speed (P7001) of 1600 rpm and a calculated Ixx69 (P7002) of 53.3334. So for this type of motor we will use the Theoretical Ixx69, being less than the calculated one.

```
I169,4,100=42.667      ; Motors 1 thru 4 Output Command Limit
```

PWM Scale Factor: Ixx66

If Motor Rated Voltage > Bus Voltage:

```
I166=1.10*I7000               ; Motor #1 PWM Scale Factor. Set to 10% above PWM Count.
I266=I166 I366=I166 I466=I166 ; Assuming same motor(s) as motor #1
```

If Bus Voltage > Motor Rated Voltage:

Ixx66 acts as a voltage limiter. In order to obtain full voltage output it is set to about 10% over PWM count divided by DC Bus/Motor voltage ratio:

```
#define DCBusInput     60      ; DC Bus Voltage -User Input

#define Mtr1Voltage    24      ; Motor 1 Rated Voltage [VDC]-User Input
#define Mtr2Voltage    24      ; Motor 2 Rated Voltage [VDC]-User Input
#define Mtr3Voltage    24      ; Motor 3 Rated Voltage [VDC]-User Input
#define Mtr4Voltage    24      ; Motor 4 Rated Voltage [VDC]-User Input

I166=1.10*I7000*Mtr1Voltage/DCBusInput       ; Motor 1 PWM Scale Factor
I266=1.10*I7000*Mtr2Voltage/DCBusInput       ; Motor 2 PWM Scale Factor
I366=1.10*I7000*Mtr3Voltage/DCBusInput       ; Motor 3 PWM Scale Factor
I466=1.10*I7000*Mtr4Voltage/DCBusInput       ; Motor 4 PWM Scale Factor
```

I2T Protection, Magnetization Current: Ixx57, Ixx58, Ixx69, Ixx77

The lower values (tighter specifications) of the Continuous/Instantaneous current ratings between the Turbo Clipper Drive and motor are chosen to setup I2T protection.

If the peak current limit chosen is that of the Turbo Clipper Drive (15 Amps) then the time allowed at peak current is set to 2 seconds.

If the peak current limit chosen is that of the Motor, check the motor specifications for time allowed at peak current.

Examples:

- For setting up I2T on a Turbo Clipper Drive driving a 3/9-Amp motor, 3 amps continuous and 9 amps instantaneous will be used as current limits. And time allowed at peak is that of the motor.

- For setting up I2T on a Turbo Clipper Drive driving a 4/16-Amp motor, 4 amps continuous and 15 amps instantaneous will be used as current limits. And time allowed at peak is 2 seconds.

The rule of thumb for Stepper magnetization current is Ixx77 = Ixx57/√2

Motors 1 thru 4 have 5-amp continuous, 15-amp peak current limits. With a servo clock of 8 KHz, I2T protection and magnetization current would be set to:

```
#define ContCurrent    5       ; Continuous Current Limit [Amps] -User Input
#define PeakCurrent    15      ; Instantaneous Current Limit [Amps] -User Input
#define MaxADC         33.85   ; Turbo Clipper Drive full range ADC reading (electrical
specifications)
;#define ServoClk      P7003   ; [KHz] Computed in Dominant Clock Settings Section
#define I2TOnTime      2       ; Time allowed at peak Current [sec]
#define VoltOutLimit   P7007   ; This is Ixx69 normally used in direct digital PWM

I157=INT(32767*(ContCurrent*1.414/MaxADC)*cos(30))
I177=I157/SQRT(2)
VoltOutLimit=INT(32767*(PeakCurrent*1.414/MaxADC)*cos(30))
I158=INT((VoltOutLimit*VoltOutLimit-I157*I157)*ServoClk*1000*I2TOnTime/(32767*32767))

I257=I157      I277=I177      I258=I158
I357=I157      I377=I177      I358=I158
I457=I157      I477=I177      I458=I158
```

Note

Software I2T is handled by Turbo PMAC. The Turbo Clipper Drive has a built-in hardware I2T protection as an additional layer of safety.

Phasing, Power-On Mode: Ixx80, Ixx73, Ixx74, Ixx81, Ixx91

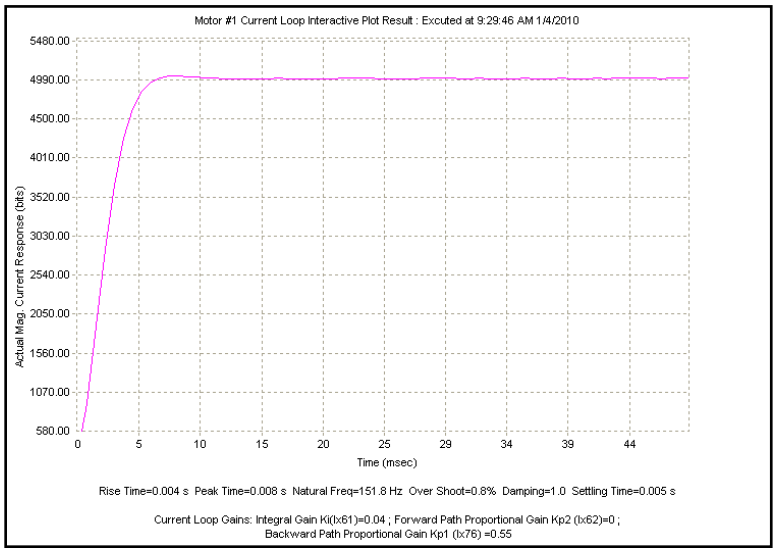
```
I180=0 I173=0 I174=0   ;
I280=0 I273=0 I274=0   ;
I380=0 I373=0 I374=0   ;
I480=0 I473=0 I474=0   ;

I181=$3503             ; Motor 1 Power-On Commutation, Integrated Output #1
I281=$3506             ; Motor 2 Power-On Commutation, Integrated Output #2
I381=$3509             ; Motor 3 Power-On Commutation, Integrated Output #3
I481=$350C             ; Motor 4 Power-On Commutation, Integrated Output #4
I191,4,100=$500000     ; Mtrs 1-4 Pwr-on Pos. format Read 16 (11+5) bits of X register Ixx81
```

Position-Loop PID Gains: Ixx30…Ixx39

```
I130,4,100=1024        ; Motor 1-4 PID Proportional Gain
I131,4,100=0           ; Motor 1-4 PID Derivitive Gain
I132,4,100=85          ; Motor 1-4 PID Velocity Feedforward Gain
I133,4,100=1024        ; Motor 1-4 PID Integral Gain
I134,4,100=1           ; Motor 1-4 PID Integration Mode
I135,4,100=0           ; Motor 1-4 PID Acceleration Feedforward Gain
I136,4,100=0           ; Motor 1-4 PID Notch Filter Coefficient N1
I137,4,100=0           ; Motor 1-4 PID Notch Filter Coefficient N2
I138,4,100=0           ; Motor 1-4 PID Notch Filter Coefficient D1
I139,4,100=0           ; Motor 1-4 PID Notch Filter Coefficient D2
```

Current-Loop Gains: Ixx61, Ixx62, Ixx76

The current-loop tuning can be performed as in any Turbo PMAC digital current loop setup. The PMACTuningPro2 automatic or interactive utility can be used to fine-tune the current loop gains. Ixx61=0.005, Ixx62=0, and Ixx76=0.05 is a good/safe starting point for interactive current-loop tuning. Typically, an acceptable current-loop step response would look like the following:



Number Of Counts Per Revolution (Stepper Motors)

With a count equal to a micro-step, and 512 micro-steps per 1.8-degree full step (2048 per cycle), you should expect to see 360*512/1.8= 102,400 counts per revolution of the motor.

Note

Some stepper motors have unconventional specifications making top speeds unattainable with the basic micro-stepping technique. Adjusting the direct current on the fly might be necessary (i.e. using open servo).

Setting Up DC Brushless Motor

Before you start

- It is always recommended to start a fresh setup from factory default settings, $$$*** followed by a Save and a $$$.
- Don't forget to create/edit the motor type and protection power-on PLC
- At this point of the setup it is assumed that the encoder has been wired and configured correctly in the Encoder Feedback section. And that moving the motor/encoder shaft by hand shows encoder counts in the position window.
- Parameters with Comments ending with **-User Input** require the user to enter information pertaining to their system/hardware.
- Downloading and using the suggested M-variables is highly recommended.
- Detailed description of motor setup parameters can be found in the Turbo SRM Manual.

Flag Control, Commutation Angle, Current Mask: Ixx24, Ixx72, Ixx84

```
I124,4,100=$800001     ; Motors 1-4 Flag control, High true amp fault (Turbo Clipper Drive
specific)
I172,4,100=683         ; Motors 1-4 Commutation phase angle (Turbo Clipper Drive specific)
I184,4,100=$FFFC00     ; Motors 1-4 Current-Loop Feedback Mask Word (Turbo Clipper Drive
specific)
```

PWM Scale Factor: Ixx66

If Motor Rated Voltage > Bus Voltage:

```
I166=1.10*I7000               ; Motor #1 PWM Scale Factor. Set to 10% above PWM Count.
I266=I166 I366=I166 I466=I166 ; Assuming same motor(s) as motor #1
```

If Bus Voltage > Motor Rated Voltage:

Ixx66 acts as a voltage limiter. In order to obtain full voltage output it is set to about 10% over PWM count divided by DC Bus/Motor voltage ratio:

```
#define DCBusInput     60      ; DC Bus Voltage -User Input

#define Mtr1Voltage    24      ; Motor 1 Rated Voltage [VDC]-User Input
#define Mtr2Voltage    24      ; Motor 2 Rated Voltage [VDC]-User Input
#define Mtr3Voltage    24      ; Motor 3 Rated Voltage [VDC]-User Input
#define Mtr4Voltage    24      ; Motor 4 Rated Voltage [VDC]-User Input

I166=1.10*I7000*Mtr1Voltage/DCBusInput       ; Motor 1 PWM Scale Factor
I266=1.10*I7000*Mtr2Voltage/DCBusInput       ; Motor 2 PWM Scale Factor
I366=1.10*I7000*Mtr3Voltage/DCBusInput       ; Motor 3 PWM Scale Factor
I466=1.10*I7000*Mtr4Voltage/DCBusInput       ; Motor 4 PWM Scale Factor
```

Current Feedback Address: Ixx82

```
I182=$078006           ; Motor 1 Current Feedback Address
I282=$07800E           ; Motor 2 Current Feedback Address
I382=$078016           ; Motor 3 Current Feedback Address
I482=$07801E           ; Motor 4 Current Feedback Address
```

Commutation Position Address, Commutation Enable: Ixx83, Ixx01

Digital Quadrature Feedback (Default)

```
I183=$078001    ; Motor 1 On-going Commutation Position Address
I283=$078009    ; Motor 2 On-going Commutation Position Address
I383=$078011    ; Motor 3 On-going Commutation Position Address
I483=$078019    ; Motor 4 On-going Commutation Position Address
I101,4,100=1    ; Motors 1-4 Commutation Enabled, from X-register
```

Sinusoidal

```
I183=I104       ; Motor 1 On-going Commutation Position Address
I283=I204       ; Motor 2 On-going Commutation Position Address
I383=I304       ; Motor 3 On-going Commutation Position Address
I483=I404       ; Motor 4 On-going Commutation Position Address
I101,4,100=1    ; Motors 1-4 Commutation Enabled, from X-register
```

I2T Protection: Ixx57, Ixx58, Ixx69

The lower values (tighter specifications) of the Continuous/Instantaneous current ratings between the drive and the motor are chosen to setup I2T protection. Examples;

Examples:

- For setting up I2T on a Turbo Clipper Drive driving a 3/9-Amp motor, 3 amps continuous and 9 amps instantaneous will be used as current limits. And time allowed at peak is that of the motor.
- For setting up I2T on a Turbo Clipper Drive driving a 4/16-Amp motor, 4 amps continuous and 15 amps instantaneous will be used as current limits. And time allowed at peak is 2 seconds.

Motors 1 thru 4 are specified to 5-amp continuous, 10-amp peak current limits.

```
;#define ServoClk       P7003   ; [KHz] Computed in Dominant Clock Settings Section
#define ContCurrent     5       ; Continuous Current Limit [Amps] -User Input
#define PeakCurrent     15      ; Instantaneous Current Limit [Amps] -User Input
#define MaxADC          33.85   ; Turbo Clipper Drive full range ADC reading (electrical
specifications)
#define I2TOnTime       2       ; Time allowed at peak Current [sec]

I157=INT(32767*(ContCurrent*1.414/MaxADC)*cos(30))
I169=INT(32767*(PeakCurrent*1.414/MaxADC)*cos(30))
I158=INT((I169*I169-I157*I157)*ServoClk*1000*I2TOnTime/(32767*32767))

I257=I157       I258=I158       I269=I169
I357=I157       I358=I158       I369=I169
I457=I157       I458=I158       I469=I169
```

Note

Software I2T is handled by Turbo PMAC. The Turbo Clipper Drive drive has a built-in hardware I2T protection as an additional layer of safety.

Commutation Cycle Size: Ixx70, Ixx71

The ratio of Ixx70/Ixx71 represents the number of encoder counts per electrical cycle. These parameters are set up with respect to the encoder type and resolution:

Digital Quadrature Feedback

Ixx70= {Number of pair poles of the motor}
Ixx71= {Number of counts per revolution}

Sinusoidal Feedback

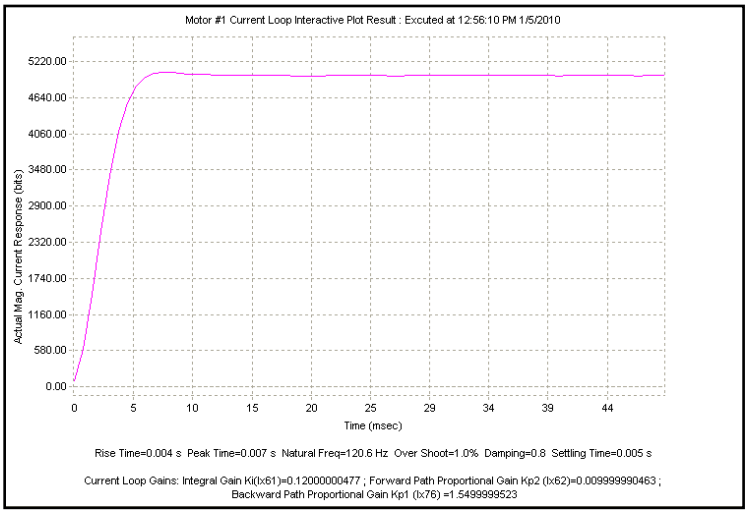
Ixx70= {Number of pair poles of the motor}
Ixx71= {Number of counts per revolution}/32 ; Commutation done using quadrature data

ADC Offsets: Ixx29, Ixx79

The ADC offsets importance may vary from one system to another, depending on the motor(s) type and application requirements. They can be left at default of zero especially if a motor setup is to be reproduced on multiple machines by copying the configuration file of the first time integration. However, they should ultimately be set to minimize measurement offsets from the A and B-phase current feedback circuits, respectively (read in Suggested M-variables Mxx05, Mxx06).

Current-Loop Gains: Ixx61, Ixx62, Ixx76

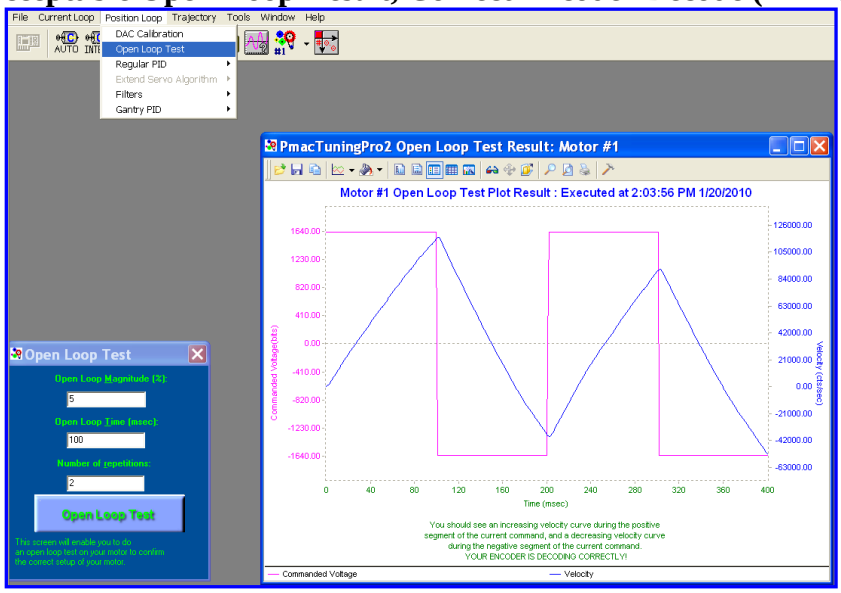
The current-loop tuning is done as in any Turbo PMAC digital current loop setup. The PMACTuningPro2 automatic or interactive utility can be used to fine-tune the Current-Loop. An acceptable Current-Loop step response would look like:



Open-Loop Test, Encoder Decode: I7mn0

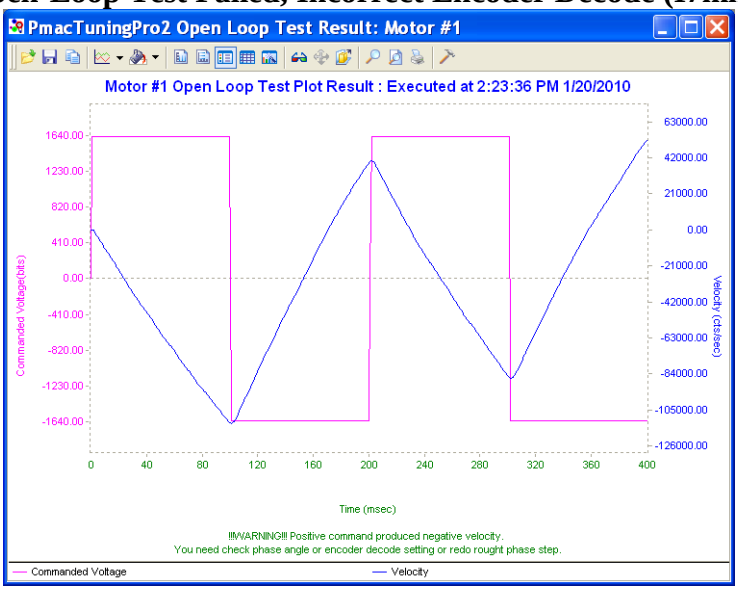
Having a satisfactory current loop, the motor can now be manually phased (i.e. custom, 2-guess, stepper method) as described in the subsequent Motor Phasing section. The open-loop test is critical to verify the direction sense of the encoder counting versus the command output.
A positive command should create a positive velocity and a position counting in the positive direction; a negative command should create a negative velocity and a position counting in the negative direction. The open-loop test can be done manually from the terminal window while gathering position, velocity data. However, the PMACTuningPro2 Software provides with a built-in automatic open loop utility that is convenient to use.

Acceptable Open-Loop Result, Correct Encoder Decode (I7mn0)


File Current Loop Position Loop Trajectory Tools Window Help
DAC Calibration
Open Loop Test
Regular PID
Extend Servo Algorithm
Filters
Gantry PID
PmacTuningPro2 Open Loop Test Result: Motor #1
Motor #1 Open Loop Test Plot Result : Executed at 2:03:56 PM 1/20/2010
Open Loop Test
Open Loop Magnitude (%):
5
Open Loop Time (msec):
100
Number of repetitions:
2
Open Loop Test
Time (msec)
You should see an increasing velocity curve during the positive segment of the current command, and a decreasing velocity curve during the negative segment of the current command.
YOUR ENCODER IS DECODING CORRECTLY!
Commanded Voltage
Velocity

The open-loop test is usually performed on an unloaded motor. The open loop command output is adjustable, start off with a conservative 1 to 2 percent command output (i.e. #nO2) value and increment gradually until you see a satisfactory result.

Open-Loop Test Failed, Incorrect Encoder Decode (I7mn0)


PmacTuningPro2 Open Loop Test Result: Motor #1
Motor #1 Open Loop Test Plot Result : Executed at 2:23:36 PM 1/20/2010
Commanded Voltage(bits)
Velocity (counts/sec)
Time (msec)
!!WARNING!! Positive command produced negative velocity.
You need check phase angle or encoder decode setting or redo rought phase step.
Commanded Voltage
Velocity

If the open-loop test fails, redo motor rough phasing and try again.
If the failure persists (inverted saw tooth, as shown in the plot above), or you observe oscillations in the response instead of a saw tooth, then most likely the direction sense of the encoder is opposite to the Brick command output.
If the motor locks in position (with an open loop command) like a stepper motor, then the phasing is either incorrect or the direction of a serial is reversed and the commutation is failing.

Troubleshooting failed Open-Loop tests:

- Change I7mn0 to 3 from 7 (default) or vice-versa
- Make Sure Ixx70, Ixx71 are correct

Motor Phasing, Power-On Mode: Ixx73, Ixx74, Ixx80, Ixx91

Turbo Clipper Drive supports a variety of phasing methods. This section discusses the following phasing methods:

- Manual/Custom
- 2-Guess
- Stepper
- Hall Effect (Digital quadrature encoders)

WARNING

An unreliable phasing search method can lead to a runaway condition. Test the phasing search method carefully to make sure it works properly under all conceivable conditions. Make sure the Ixx11 fatal following error limit is active and as tight as possible so the motor will be killed quickly in the event of a serious phasing search error.

Manual Phasing Method: Useful for troubleshooting and testing for "good" phase finding output value used in 2-guess or stepper method. It can be used regardless of the type of feedback. The manual phasing method consists of locking the motor tightly to one of its phases and resetting the Phase position register in PMAC. It is useful for troubleshooting, rough phasing and testing for a "good" phase finding output value.
Steps to follow, or implement in a PLC:

a. Record the values of Ixx29, and Ixx79 to restore them at the end of test.
b. Set Ixx29=0, and write a positive value to Ixx79 then issue a #nO0.
   500 is a reasonable conservative starting value for Ixx79. Adjust appropriately (most likely increase) to force the motor (unloaded) to lock tightly onto a phase.
c. Set Phase Position register to zero, Suggested M-Variable Mxx71=0
d. Issue a #nK to kill the motor
e. Restore Ixx29, and Ixx79 to their original values
f. Clear Phasing search error bit, Suggested M-Variable Mxx48=0
g. The motor is now ready to jog/close the loop

Motor 1 Manual Phasing Example PLC:

```
#define Mtr1PhasePos          M171    ; Motor 1 Phase Position Register, Suggested M-Variable
Mtr1PhasePos->X:$B4,0,24,S
#define Mtr1PhaseErrBit       M148    ; Mtr1 Phasing Search Error Bit, Suggested M-Variable
Mtr1PhaseErrBit->Y:$C0,8

Open plc 3 clear
I5112=500*8388608/I10 while(I5112>0) Endw
P129=I129 P179=I179    ; Store Ixx29, and Ixx79
I129=0 I179=1000       ; Set Ixx29=0 and Ixx79 to positive value (adjustable)
I5112=100*8388608/I10 while(I5112>0) Endw    ; 100 msec delay
CMD"#1o0"              ; Issue 0% open loop command output
I5112=3000*8388608/I10 while(I5112>0) Endw   ; 3 seconds delay to allow motor to settle
Mtr1PhasePos=0         ; Set phase register to zero
I5112=500*8388608/I10 while(I5112>0) Endw    ; 1/2 second delay
CMD"#1K"               ; Kill Motor
I5112=100*8388608/I10 while (I5112>0) Endw   ; 100 msec delay
I129=P129 I179=P179    ; Restore Ixx29 and Ixx79 to original values
Mtr1PhaseErrBit=0      ; Clear Phasing search error bit
I5112=500*8388608/I10 while (I5112>0) Endw   ; 1/2 second delay
Dis plc 3              ; Disable PLC, run only once
close
```

2-Guess Phasing Method: Rough phasing method for motors with relatively small loads or quick setups for testing. Typical (example) values:

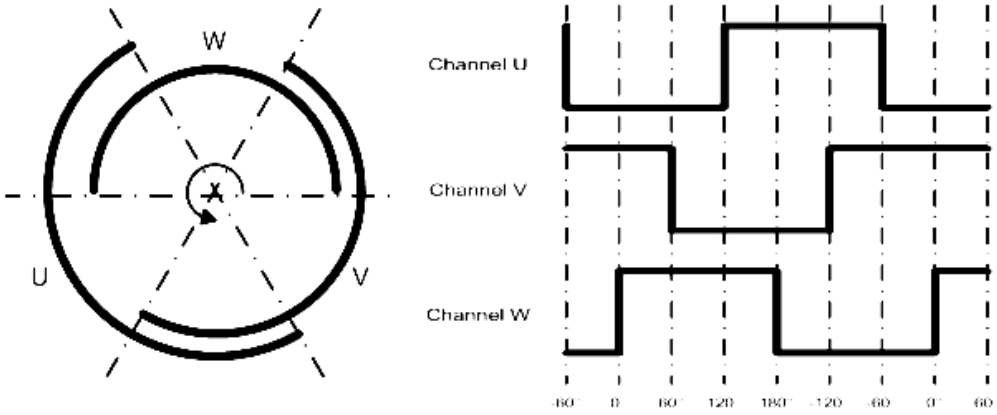
Ixx73=1200 ; Phase Finding Output Value (Adjustable). Units of 16-bit DAC
Ixx74=8 ; Units of Servo Cycles
Ixx80=4 ; 2-guess method, no absolute position read, no power-on phasing

Stepper Phasing Method: Finer than the 2-guess method, usually used on motors with significant loads. Typical (example) values:

Ixx73=1200 ; Phase Finding Output Value (Adjustable). Units of 16-bit DAC
Ixx74=80 ; Units of Servo Cycles * 256
Ixx80=6 ; Stepped method, no absolute position read, no power-on phasing

Hall Effect Phasing (Digital Quadrature Encoders):

Digital hall sensors provide three digital signals that are a function of the position of the motor shaft, each nominally with 50% duty cycle, and nominally 1/3 cycle apart (This format is often called 120° spacing; the Turbo Clipper Drive Drive has no automatic hardware or software features to work with 60° spacing.) The 120° spacing format provides six distinct states per cycle of the signal. Typically, one cycle of the signal set corresponds to one electrical cycle, or pole pair of the motor. These sensors can then provide absolute (if low resolution) information about where the motor is in its commutation cycle, and eliminate the need to do a power-on phasing search operation. The 3-phase digital Hall effects can be used with the Turbo Clipper Drive as low-resolution position/velocity sensors but typically they are used to accomplish a rough power-up phasing.

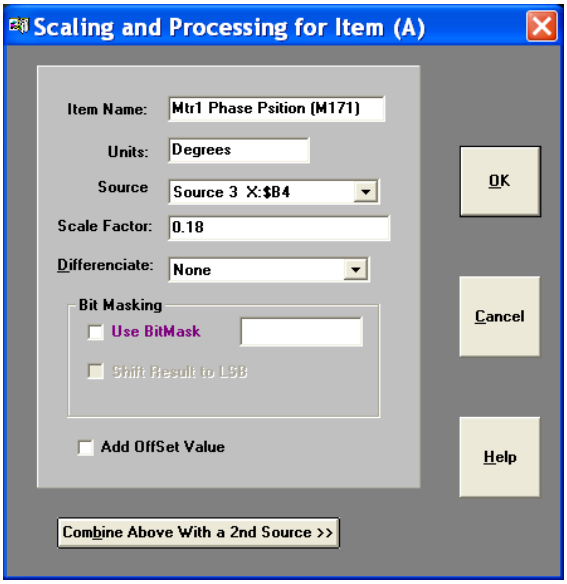


Hall sensors have an error of about ±30° resulting a loss in torque of about 15%, it will need to be corrected (fine phasing) for top operation.

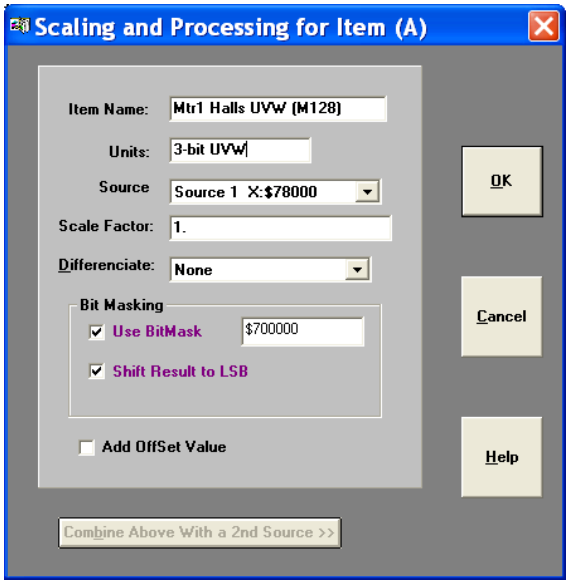
Hall Effect phasing with the Brick can be setup following these steps:

a. Set Ixx81=0, and Ixx91=0 (which effectively are the parameters to be configured for hall effect phasing)
b. Phase the motor as best as possible using custom, 2-guess, or stepper method
c. Jog the motor slowly (with rough PID gains), or move in open loop in the positive direction of the encoder while plotting (Mxx28) Halls UVW versus Phase Position (Mxx71).
d. Setting up the detailed plot, Scaling and Processing of Halls UVW, Phase Position

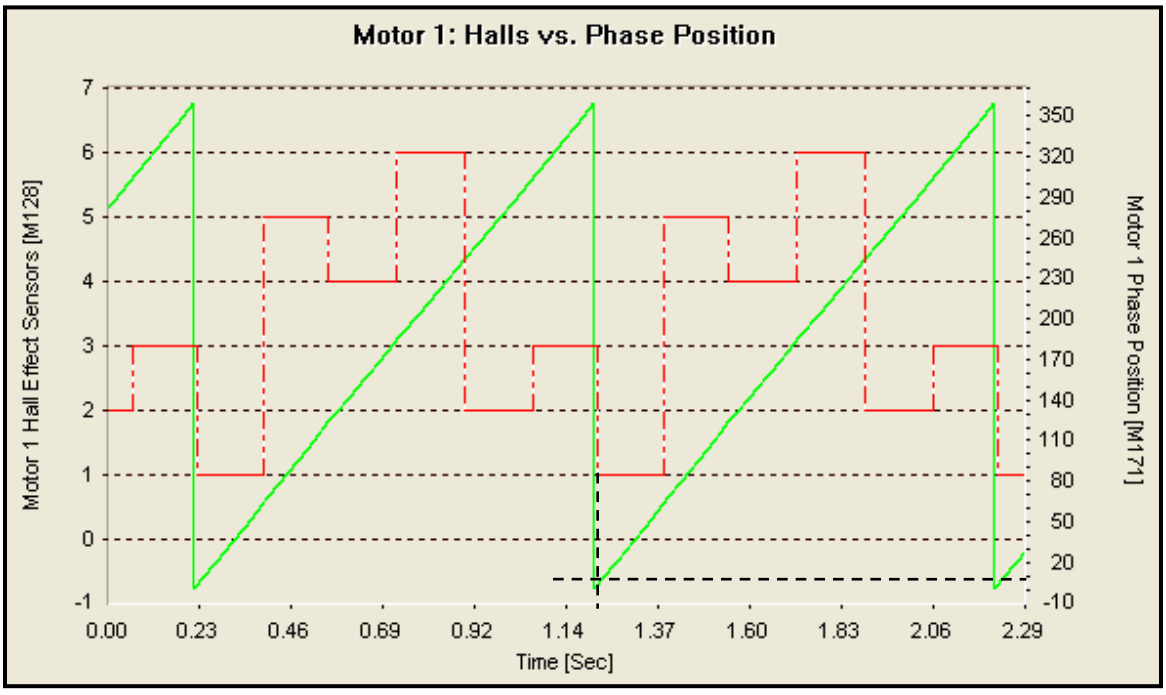
e. Gathering, and plotting data for a short travel of the motor should look like (remember to kill the motor when the gathering is finished):



The scale factor is used to scale the phase position to 0 - 360°. It is equal to 360/Ixx71.



$700000 Masking enables reading W, V, and U bits 20, 21, and 22 respectively



Primarily, we are interested in two occurrences on the plot; the transition of the halls data between states 1 & 3, and the point of intersection of Mxx28 and Mxx71 at this transition, which represents the Hall Effect Zero (HEZ).

If the Halls transition goes from 3 to 1 (with positive movement of the motor) as shown in the plot, bit #22 of Ixx91 is set to 1 for reversed direction. Use this definition in deriving Ixx91:

```
#define Mtr1UVTrans3_1 M7025                ; Reversed direction: 3 to 1
Mtr1UVTrans3_1->*
Mtr1UVTrans3_1=$C00000
```

If the Halls transition goes from 1 to 3 (with positive movement of the motor), bit #22 of Ixx91 is set to 0 for standard direction. Use this definition in deriving Ixx91:

```
#define Mtr1UVTrans1_3 M7025                ; Standard direction: 1 to 3
Mtr1UVTrans1_3->*
Mtr1UVTrans1_3=$800000
```

The HEZ is derived from plot, showing about 5 degrees in the example plot.

f. Setting Ixx81, Deriving Ixx91

Power-On Phase Position Address Ixx81 Hall Effect	
Channel 1	$78000
Channel 2	$78008
Channel 3	$78010
Channel 4	$78018

Channel 1 is setup for Hall Effect phasing. The example plot reveals that the direction is reversed, and the HEZ is about 5 degrees:

```
I181=$78000                          ; Channel 1 Power-On Phase Position Address
#define HEZ           P7025          ; Hall Effect Zero
HEZ=5                                ; Degrees -User Input
#define HEZTemp       P7026          ; Temporary User Variable
HEZTemp = INT(((HEZ%360)/360)*64)    ; Processing Hall Effect Zero
I191=(HEZTemp*65536)+Mtr1UVTrans3_1  ; Shift 16 bits left and set transition bit
```

Resulting I191=$C00000

g. Save Ixx81, Ixx91 parameters to the Turbo Clipper Drive after satisfactory testing; meaning cycling power a few times, moving the motor to random locations attempt to phase and issue jog or open loop commands reliably.

h. Hall Effect fine phasing (optional): The idea is to phase the motor manually as tight as possible, and use a point of reference (known repeatable location) along the travel of the motor to record the phase position (Mxx71). This is a one-time test per installation. On subsequent power-ups, the motor is phased using Hall Effect sensors and moved to that reference point, where the phase position is overwritten by the value recorded from the manual-phasing reference test. The most repeatable reference location is usually the home position of the motor, which is most reliably achieved using position capture with a combination of flag and index pulse.

Example: Channel 1 is driving a motor with home capture done using home flag and index pulse high true. The recorded phase position from manual phasing reference test was found to be 330, and stored (saved) in a user defined variable. Setup and fine phasing example PLC:

```
I7012=3 ; Motor 1 Capture Control, Index high and Flag high
I7013=0 ; Motor 1 Capture Control flag select, Home Flag

#define Mtr1DesVelZero        M133    ; Motor 1 Desired-velocity-zero bit, Suggested M-Variable
Mtr1DesVelZero->X:$0000B0,13,1        ;
#define Mtr1InPosBit          M140    ; Motor 1 Background in-position bit, Suggested M-Variable
Mtr1InPosBit->Y:$0000C0,0,1           ;
#define Mtr1PhasePos          M171    ; Motor 1 Phase Position Register, Suggested M-Variable
Mtr1PhasePos->X:$B4,0,24,S            ;
#define Mtr1RecPhasePos       P7027   ;
Mtr1RecPhasePos=330                   ; Recorded Phase Position (Manual phasing reference test)

Open plc 3 clear
I5311=500*8388608/I10 while(I5311>0)Endw            ; 1/2 sec delay
CMD"#1$"                                            ; Phase motor, using Hall Effect Sensors
I5311=50*8388608/I10 while(I5311>0)Endw             ; 50 msec Delay
While(Mtr1DesVelZero=0 or Mtr1InPosBit=0) Endw      ; Wait until motor settles, and in position
CMD"#1hm"                                           ; Issue a home command
I5311=50*8388608/I10 while(I5311>0)Endw             ; 50 msec Delay
While(Mtr1DesVelZero=0 or Mtr1InPosBit=0)Endw       ; Wait until motor settles, and in position
Mtr1PhasePos =Mtr1RecPhasePos                       ; Adjust Phase Position
I5311=500*8388608/I10 while(I5311>0)Endw            ; 1/2 sec delay
CMD"#1K"                                            ; Kill Motor (Optional)
Disable plc 3                                       ; Execute only once
Close
```

Delta Tau provides an automatic Hall Effect setup software utility as an alternative to the manual Hall Effect setup. This can be found at Delta Tau Forums Online.

Note

The automatic software utility requires jogging the motor; make sure the motor is phased (custom, 2-guess, or stepper method) and that the position-loop PID tuning is acceptable.

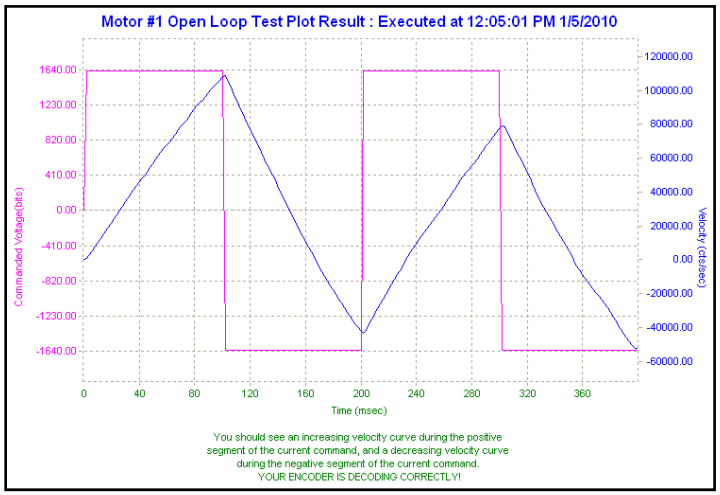
Position-Loop PID Gains: Ixx30…Ixx39

The position-loop tuning is done as in any Turbo PMAC PID-Loop setup. The PMACTuningPro2 automatic or interactive utility can be used for fine tuning.

WARNING

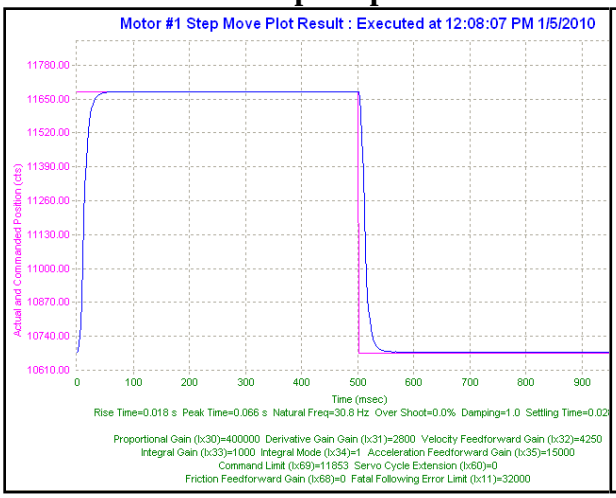
Remember to perform an Open Loop Test (if you have not already) before trying to close the loop to make sure that the encoder decode (I7mn0) is correct. Essentially a positive open loop command should result in position direction (of the encoder) motion and vice-versa.

Good Open Loop Test

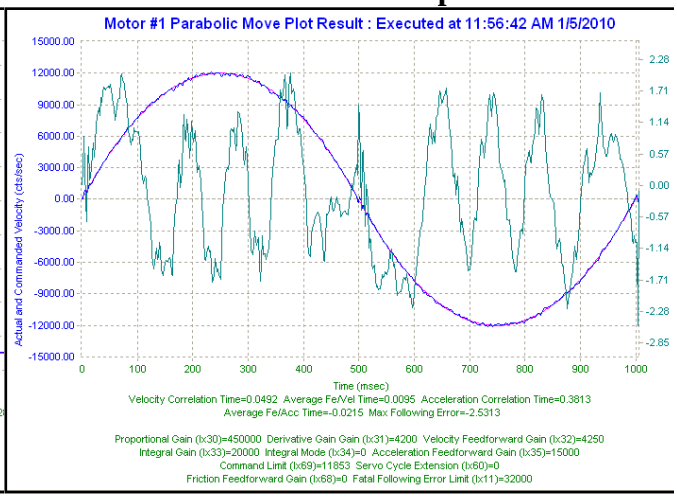

Motor #1 Open Loop Test Plot Result : Executed at 12:05:01 PM 1/5/2010
Commanded Voltage(bits)
Velocity (cts/sec)
Time (msec)
You should see an increasing velocity curve during the positive segment of the current command, and a decreasing velocity curve during the negative segment of the current command.
YOUR ENCODER IS DECODING CORRECTLY!

Acceptable Step and Parabolic position responses should look like the following:

Position Step Response


Motor #1 Step Move Plot Result : Executed at 12:08:07 PM 1/5/2010
Actual and Commanded Position (cts)
Time (msec)
Rise Time=0.018 s Peak Time=0.066 s Natural Freq=30.8 Hz Over Shoot=0.0% Damping=1.0 Settling Time=0.02
Proportional Gain (Ix30)=400000 Derivative Gain Gain (Ix31)=2800 Velocity Feedforward Gain (Ix32)=4250
Integral Gain (Ix33)=1000 Integral Mode (Ix34)=1 Acceleration Feedforward Gain (Ix35)=15000
Command Limit (Ix69)=11853 Servo Cycle Extension (Ix60)=0
Friction Feedforward Gain (Ix68)=0 Fatal Following Error Limit (Ix11)=32000

Position Parabolic Response


Motor #1 Parabolic Move Plot Result : Executed at 11:56:42 AM 1/5/2010
Actual and Commanded Velocity (cts/sec)
Time (msec)
Velocity Correlation Time=0.0492 Average Fe/Vel Time=0.0095 Acceleration Correlation Time=0.3813
Average Fe/Acc Time=-0.0215 Max Following Error=-2.5313
Proportional Gain (Ix30)=450000 Derivative Gain Gain (Ix31)=4200 Velocity Feedforward Gain (Ix32)=4250
Integral Gain (Ix33)=20000 Integral Mode (Ix34)=0 Acceleration Feedforward Gain (Ix35)=15000
Command Limit (Ix69)=11853 Servo Cycle Extension (Ix60)=0
Friction Feedforward Gain (Ix68)=0 Fatal Following Error Limit (Ix11)=32000

Setting Up DC Brush Motor

Before you start

- It is always recommended to start a fresh setup from factory default settings, $$$*** followed by a Save and a $$$.
- Don't forget to create/edit the motor type and protection power-on PLC
- At this point of the setup it is assumed that the encoder has been wired and configured correctly in the Encoder Feedback section. And that moving the motor/encoder shaft by hand shows encoder counts in the position window.
- Parameters with Comments ending with **-User Input** require the user to enter information pertaining to their system/hardware.
- Downloading and using the suggested M-variables is highly recommended.
- Detailed description of motor setup parameters can be found in the Turbo SRM Manual.

Phasing Search Error Bit, Current-Loop Integrator Output

On power-up, the phasing search error bit has to be cleared to allow motor move commands to DC Brush motor. This can be added to the power-on PLC. Also, the current-loop integrator output should not be allowed to build up over time. The motor (non-existent) direct current-loop output should be zero-ed periodically.

```
M148->Y:$C0,8,1        ; Motor 1 Phasing error fault bit
M248->Y:$140,8,1       ; Motor 2 Phasing error fault bit
M348->Y:$1C0,8,1       ; Motor 3 Phasing error fault bit
M448->Y:$240,8,1       ; Motor 4 Phasing error fault bit
M601->Y:$BC,0,24,U     ; Motor 1 Direct Current-Loop Integrator Output
M602->Y:$13C,0,24,U    ; Motor 2 Direct Current-Loop Integrator Output
M603->Y:$1BC,0,24,U    ; Motor 3 Direct Current-Loop Integrator Output
M604->Y:$23C,0,24,U    ; Motor 4 Direct Current-Loop Integrator Output
Open plc 2 clear
If (M148=1)
 CMD"M148,4,100=0"             ; Clear Phasing Error Bit
EndIF
M601=0 M602=0 M603=0 M604=0    ; Zero Current-Loop Integrator Output
Close                          ; This PLC has to be active always
```

Flag Control, Commutation Enable, Phase Angle, Current Mask: Ixx24, Ixx01, Ixx72, Ixx84

```
I124,4,100=$800001     ; Motors 1-4 Flag control, High true amp fault (Turbo Clipper Drive
specific)
I101,4,100=1           ; Motors 1-4 Commutation enabled
I172,4,100=512         ; Motors 1-4 Commutation phase angle (Turbo Clipper Drive specific)
I184,4,100=$FFFC00     ; Motors 1-4 Current-Loop Feedback Mask Word(Turbo Clipper Drive specific)
```

PWM Scale Factor: Ixx66

If Motor Rated Voltage > Bus Voltage:

```
I166=1.10*I7000                ; Motor #1 PWM Scale Factor. Set to 10% above PWM Count.
I266=I166 I366=I166 I466=I166 ; Assuming same motor(s) as motor #1
```

If Bus Voltage > Motor Rated Voltage:

Ixx66 acts as a voltage limiter. In order to obtain full voltage output it is set to about 10% over PWM count divided by DC Bus/Motor voltage ratio:

```
#define DCBusInput     60      ; DC Bus Voltage -User Input

#define Mtr1Voltage    24      ; Motor 1 Rated Voltage [VDC]-User Input
#define Mtr2Voltage    24      ; Motor 2 Rated Voltage [VDC]-User Input
#define Mtr3Voltage    24      ; Motor 3 Rated Voltage [VDC]-User Input
#define Mtr4Voltage    24      ; Motor 4 Rated Voltage [VDC]-User Input

I166=1.10*I7000*Mtr1Voltage/DCBusInput       ; Motor 1 PWM Scale Factor
I266=1.10*I7000*Mtr2Voltage/DCBusInput       ; Motor 2 PWM Scale Factor
I366=1.10*I7000*Mtr3Voltage/DCBusInput       ; Motor 3 PWM Scale Factor
I466=1.10*I7000*Mtr4Voltage/DCBusInput       ; Motor 4 PWM Scale Factor
```

Current Feedback Address: Ixx82

```
I182=$078006   ; Motor 1 Current Feedback Address
I282=$07800E   ; Motor 2 Current Feedback Address
I382=$078016   ; Motor 3 Current Feedback Address
I482=$07801E   ; Motor 4 Current Feedback Address
```

Commutation Cycle Size: Ixx70, Ixx71

Set to zero with DC brush motors, commutation is done mechanically.

```
I170=0 I171=0  ; Motor 1 size and number of commutation cycles
I270=0 I271=0  ; Motor 2 size and number of commutation cycles
I370=0 I371=0  ; Motor 3 size and number of commutation cycles
I470=0 I471=0  ; Motor 4 size and number of commutation cycles
```

I2T Protection, Magnetization Current: Ixx57, Ixx58, Ixx69, Ixx77

The lower values (tighter specifications) of the Continuous/Instantaneous current rating between the drive and the motor are chosen to setup I2T protection.

Examples:

- For setting up I2T on a Turbo Clipper Drive driving a 3/9-Amp motor, 3 amps continuous and 9 amps instantaneous will be used as current limits. And time allowed at peak is that of the motor.
- For setting up I2T on a Turbo Clipper Drive driving a 4/16-Amp motor, 4 amps continuous and 15 amps instantaneous will be used as current limits. And time allowed at peak is 2 seconds.

Motors 1 thru 8 are specified to 5-amp continuous, 10-amp peak current limits:

```
#define ServoClk       P7003   ; [KHz] Computed in Dominant Clock Settings Section

#define ContCurrent    5       ; Continuous Current Limit [Amps] -User Input
#define PeakCurrent    15      ; Instantaneous Current Limit [Amps] -User Input
#define MaxADC         33.85   ; Turbo Clipper Drive full range ADC reading (electrical
specifications)

#define I2TOnTime      2       ; Time allowed at peak Current [sec]

I157=INT(32767*(ContCurrent*1.414/MaxADC)*cos(30))
I169=INT(32767*(PeakCurrent*1.414/MaxADC)*cos(30))
I158=INT((I169*I169-I157*I157)*ServoClk*1000*I2TOnTime/(32767*32767))

I257=I157      I258=I158      I269=I169
I357=I157      I358=I158      I369=I169
I457=I157      I458=I158      I469=I169
```

Note

Software I2T is handled by Turbo PMAC. The Turbo Clipper Drive drive has a built-in hardware I2T protection as an additional layer of safety.

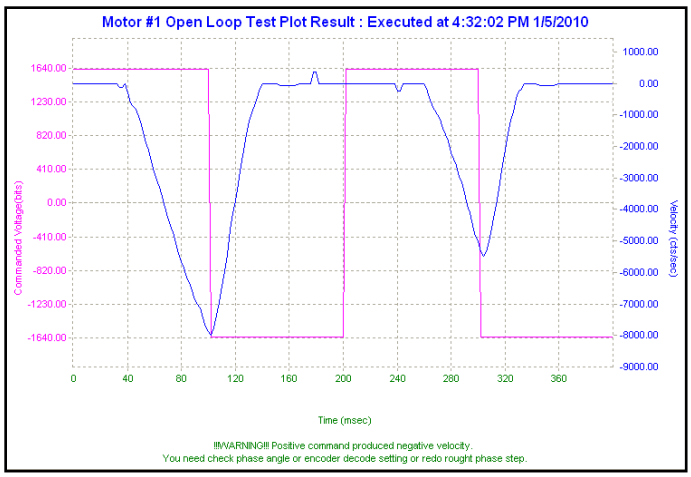
ADC Offsets: Ixx29, Ixx79

The ADC offsets importance may vary from one system to another, depending on the motor(s) type and application requirements. They can be left at default of zero especially if a motor setup is to be reproduced on multiple machines by copying the configuration file of the first time integration. However, they should ultimately be set to minimize measurement offsets from the A and B-phase current feedback circuits, respectively (read in Suggested M-variables Mxx05, Mxx06).

Current-Loop Gains, Open-Loop/Enc. Decode: Ixx61, Ixx62, Ixx76, I7mn0

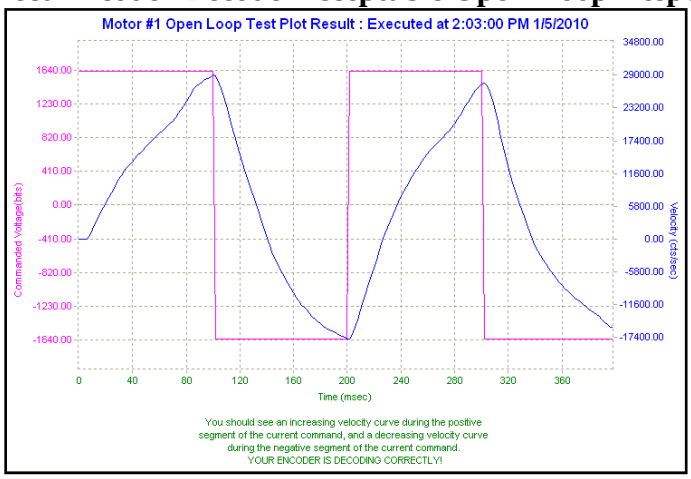
Tuning (fine) the current loop with DC brush motors is neither critical nor required. Set Ixx61 to a conservative value (i.e. 0.001) and perform an open-loop test. Essentially a positive open loop command should result in position direction (of the encoder) motion and vice-versa:

Reversed Encoder Decode. I7mn0 needs adjustment



Once the Encoder Decode is verified, increment Ixx61 gradually and redo the Open-Loop test until a solid saw tooth response is observed. Note that further increasing Ixx61 will not improve the performance.

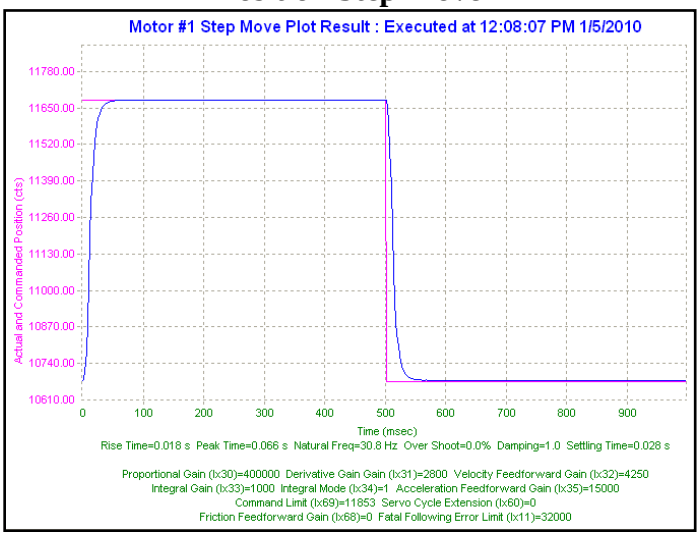
Correct Encoder Decode-Acceptable Open-Loop Response



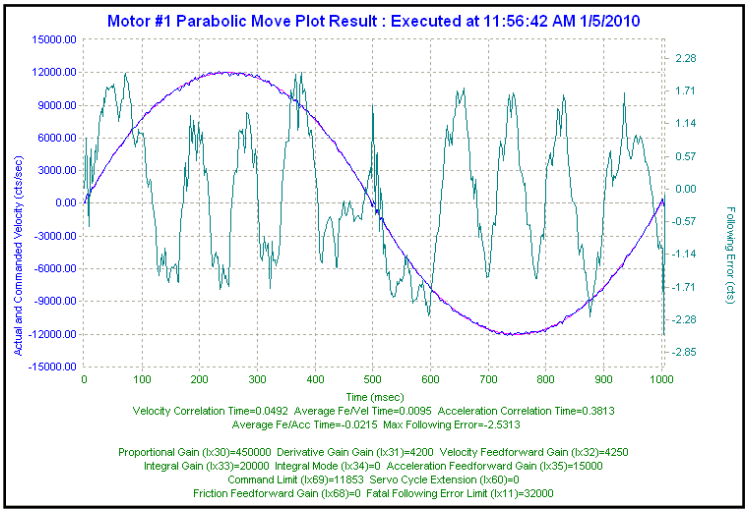
Position-Loop PID Gains: Ixx30…Ixx39

The position-loop tuning is done as in any Turbo PMAC PID-Loop setup. The PMACTuningPro2 automatic or interactive utility can be used to fine-tune the PID-Loop. Acceptable Step and Parabolic position responses would look like:

Position Step Move



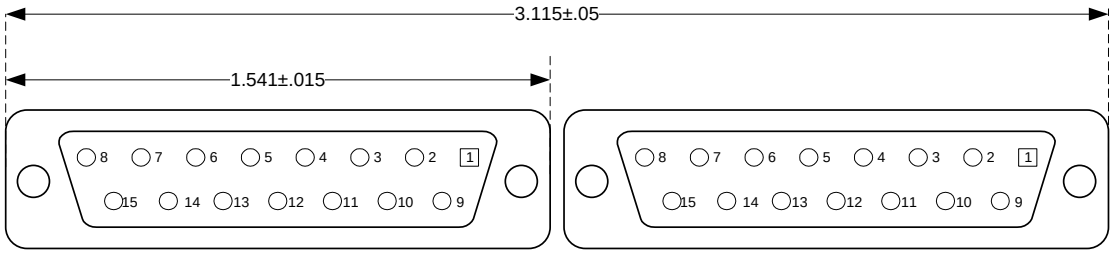
Position Parabolic Move



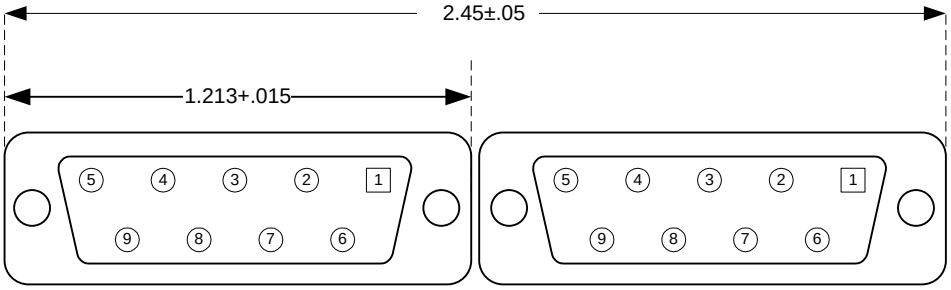
APPENDIX A

D-Sub Connector Spacing Specifications

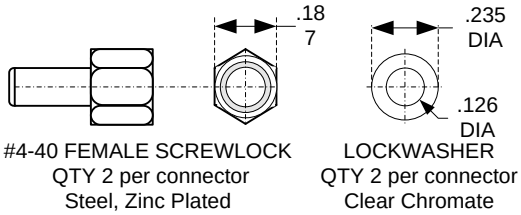
J11-J14: DA-15 Connectors for encoder feedback



DE-9 Connectors for External Amps

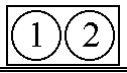


Screw Lock Size for all D-sub connectors



APPENDIX B: CLIPPER BOARD E-POINT JUMPERS

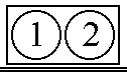
E0: Forced Reset Control

E-Point	Description	Default
E0 	Factory use only; the board will not operate with E0 installed.	Not Installed

E3: Re-Initialization On Reset Control

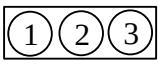
E-Point	Description	Default
E3	• Remove Jumper for normal operation. • Jump 1-2 for re-initialization on power-up.	Not Installed

E4: Watchdog Disable Jumper

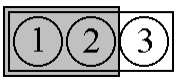
E-Point	Description	Default
E4 	• Remove Jumper for normal operation. • Install Jumper to disable watchdog timer.	Not Installed

E5: Reserved for factory use only

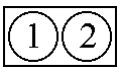
Revision 102 or newer

E Point	Description	Default
E5 	For factory use only; the board will not communicate via Ethernet or USB if jumper E5 is installed.	Not Installed

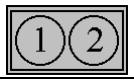
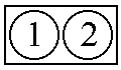
Revision 101 or older

E Point	Description	Default
E5 	For factory use only; the board will not communicate via Ethernet unless Jumper is installed on pins 1 to 2.	Jumpered 1-2

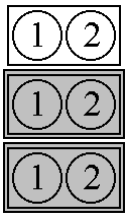
E6: ADC Inputs Enable

E-Point	Description	Default
E6  	• Remove jumper to disable Option-12 ADC inputs, which is necessary for reading current feedback signals from digital amplifiers. • Install Jumper to read ADC inputs (Only used when power board is not present)	Not Installed

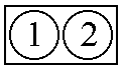
E7 – E8: USB/Ethernet Reset Jumpers

E-Point	Description	Default
E7  	Install E7 for normal operation (factory use only, do not remove)	Jumpered
E8  	• Install E8 to reload communication Boot/Firmware, or change IP address. • Remove E8 for normal operation.	Not Installed

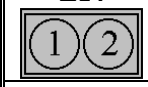
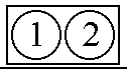
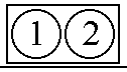
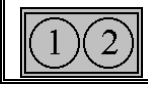
E10 – E12: Flash IC Jumpers

E Point	Description	Default
E10  **E12**	• Remove E10, jumper E11, and E12 to read flash IC on power-up/reset. • Other combinations are for factory use only.	E10 Not Installed E11-E12 Jumpered

E13: Power-Up/Reset Load Firmware

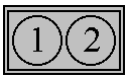
E Point	Description	Default
E13 	• Jump pin 1 to 2 to reload Turbo PMAC2 firmware. • Remove jumper for normal operation.	Not Installed

E14- E17: Ports Direction Control

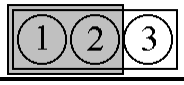
E Point	Description	Default
E14 	• Install jumper to make DATx lines inputs. • Remove jumper to make DATx lines outputs.	Jumpered
E15 	• Install jumper to make SELx lines inputs. • Remove jumper to make SELx lines outputs.	Not Installed
E16 	• Install jumper to make MOx lines inputs. • Remove jumper to make MOx lines outputs.	Not Installed
E17 	• Install jumper to make MIx lines inputs. • Remove jumper to make MIx lines outputs.	Jumpered

APPENDIX C: BREAKOUT BOARD E-POINT JUMPERS

J36: GPO E-Stop Automatic Feature

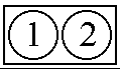
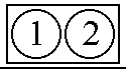
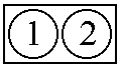
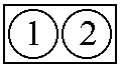
E-Point	Description	Default
J36 	• Install jumper to disable the GPO E-Stop automatic feature (outputs unaffected by E-Stop status). • Remove Jumper to enable the GPO E-Stop automatic feature (turn outputs off when in E-Stop)	Jumpered

J39: User Flag 4 E-Stop Status

E-Point	Description	Default
J39 	• Jump 1 to 2 to use User Flag 4 as an E-Stop status in software. • Jump 2 to 3 to use User Flag 4 as a general purpose user input.	Jumpered 1-2

APPENDIX D: POWER BOARD E-POINT JUMPERS

E1- E2- E3- E4: E-Stop and Reset Control

E-Point	Description	Default
E1 	• Remove jumper to enable the hard E-Stop function. • Install jumper to disable the hard E-Stop function.	Not Installed
E2 	• Remove jumper to enable both hard & soft E-Stop functions. • Install jumper to disable both hard & soft E-Stop functions.	Not Installed
E3 	• Remove jumper to enable the soft E-Stop function. • Install jumper to disable the soft E-Stop function (Soft E-Stop bit has to be set, and saved to 1).	Not Installed
E4 	• Remove jumper to use normally-open Reset switch between pin 1 and 2 of J13. • Install jumper to use normally-closed Reset switch between pin 1 and 2 of J13.	Not Installed